POWER PLANT ENGINEERING

Established Over 34 Years

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Lo! the Rich Indian

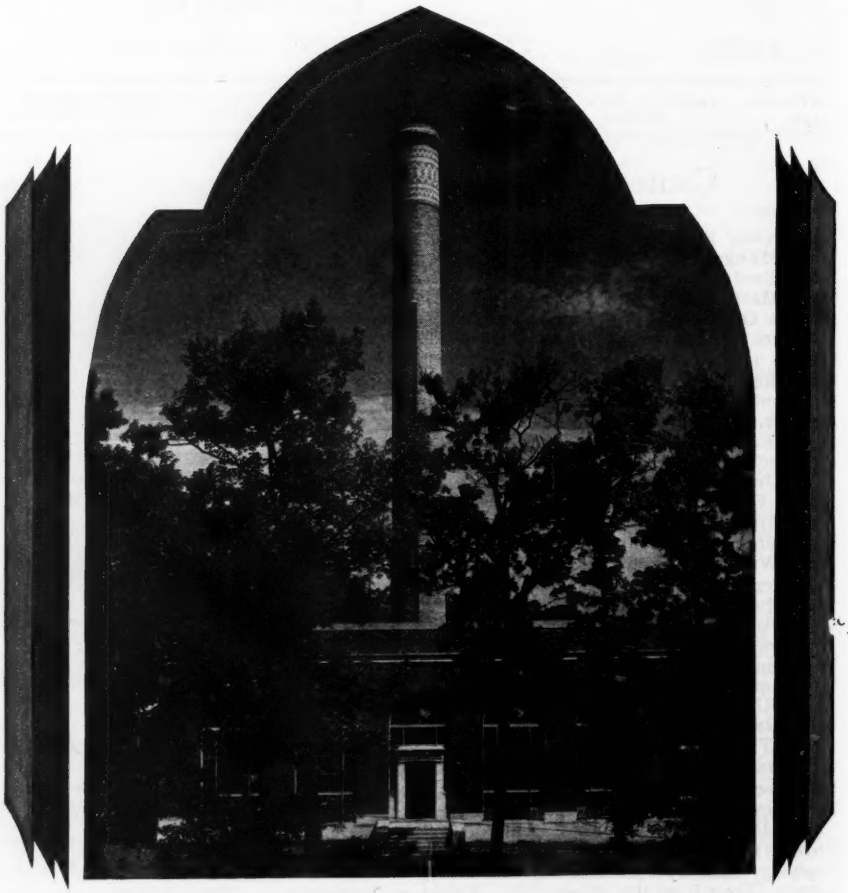
HE USED TO be Lo! the poor Indian but, according to reliable observers, if he is not always rich nowadays, he is at least much more prosperous than he used to be. As evidence of this we have the above photograph of Lo himself with his sisters and his brothers and his uncles and his aunts of the Pima tribe—not to mention their progeny—looking over the new Coolidge Dam, built largely for their benefit by the Great White Father at Washington.

When it was finished, a great ceremony was held on March 4, at which Calvin Coolidge dedicated the structure. After the white man's ceremonies were finished, the Indians again dedicated the dam in their own tongue. Thus they were photographed by Keystone View Co.

Coolidge Dam is unusual in many ways. It is one of the largest multiple-dome type dams ever built. Situated on the Gila River, nine miles below its confluence with the San Carlos, it provides a storage capacity of 1,200,000 acre-ft. Total overall length of the dam is 920 ft.; the domes are 180 ft. wide and 251 ft. high. Under the center dome is the power house containing two 9,200-hp. water-wheels driving two 6250-kv-a., 6000-v. generators.

If you are interested in large dams, you will find on page 575 of this issue a description of the largest earth-filled dam yet constructed. By way of contrast with this, you will also find on page 576 a description of a group of small dams on the Mongaup River near New York City.

New Power Plant Serves Needs of Bureau of Standards Buildings



ARCHITECTURAL FEATURES OF BUILDING AND LANDSCAPING OF SURROUNDINGS ARE IMPORTANT FEATURES IN DESIGN OF THIS PLANT WHICH SUPPLIES POWER, HEAT, LIGHT, REFRIGERATION AND COMPRESSED AIR TO THE INSTITUTION

By O. L. Britt,

Supt. of Mechanical Plant, National Bureau of Standards

ORIGINALLY THE HEATING and power plant of the Bureau of Standards of the Department of Commerce at Washington, D. C., was designed to meet the needs of the Bureau when it was first established in its present location in 1903 and occupied a part of one of the two original buildings. As the bureau has grown during the past 27 yr. from the two original buildings to eleven major buildings of permanent masonry construction and seven minor buildings of various sizes and of less permanent construction, the need for increased plant facilities was keenly felt.

Congress appropriated funds for the construction of the heating and power plant building in 1927 and construction work on the building was started in October of that year and finished in May the following year. Appropriations for equipment were made in 1927-28-29.

Operation of the boiler room section of the plant was begun in August of last year. The engine room equipment is being installed at present and will be in operation within a few months.

With respect to the other bureau buildings, the location of the plant is shown in the airplane view, Fig. 1, and on the grounds plan, Fig. 2. This site was selected so as to be nearly central with the group of buildings as finally developed and occupies land not well adapted for the laboratory type of building.

Inasmuch as the bureau is located in a high-class residential section of the city of Washington, every effort was made in the design of the building to secure one that was good from an architectural viewpoint. This required the elimination of the usual power-plant identification features such as outside coal storage, ash hoppers, hoist towers, coal receiving hoppers, protruding exhaust heads, etc. These necessary auxiliaries were housed within or skilfully concealed by the building. If it were not for the chimney and spray cooling pond which obviously could not be concealed, one could not identify the power plant as such from external appearances. The head piece to this article shows an external view of the building. The absence of large access doors excepting the door to the coal receiving room, is a notable feature. The elimination of large doors is made possible by the design of the windows which are equipped with removable steel sash, thus making it possible to move large pieces of equipment through these openings.

As a water-cooling system is necessary in conjunction with the plant condensing system, a spray-pond was selected instead of cooling-towers as the former lends itself to artistic treatment more readily than the

latter. How well such treatment has been applied may be judged from Fig. 3 which shows the spray pond as it will appear when finished.

Figure 4 is a plan view of the building at the engine room operating floor level, the location of the boilers, pump room and coal delivery room at the boiler room level being shown dotted. It will be noted that the coal receiving hopper is located in a small room at the end of the building and is accessible to coal trucks through a large doorway which is equipped with a rolling metal-slat door. As no railroad sidings are accessible, all coal is delivered by dump-body trucks. The ash bin is located within the building directly above the coal receiving hopper.

It will be noted that space for a switch room is provided over a part of the boiler room. This arrangements permits the installation of the switchboard flush with the wall and thus obviates the necessity of installing the switchboard, oil switches, bus structure, etc., in the engine room proper. This feature adds much to the neatness of the engine room. The storage battery room is shown directly back of the switch room.

Figure 5 is a sectional elevation of the building, showing the arrangement of some of the equipment. This section shows clearly the difference in elevation of the various floors, road levels and pipe tunnel connections to the building.

Coal Handling and Storage

Coal handling equipment consists of a Link-Belt Co. pivoted-bucket conveyor which receives coal through a reciprocating feeder located at the bottom of the receiving hopper, elevates to the height of the bunker and distributes the coal to any part of the bunker desired by means of a movable tripper.

The bunker is of the suspended steel-plate type and has a capacity of approximately 400 t. No outside storage is provided for, inasmuch as the bunker has sufficient capacity to carry the plant over any period of delay in coal delivery that may occur due to weather conditions or breakdown of transportation facilities.

No coal crusher is provided, due to the fact that no difficulty is experienced in getting an ample supply of screenings which requires no pre-crushing.

An electrically-propelled automatic weigh larry is provided to take coal from any section of the bunker and deliver it to any pulverizer floor-hopper. The larry-hopper has a capacity of approximately 2000 lb. and is provided with a Richardson automatic scale which delivers the coal to the hoppers in lots of 400 lb.

Pulverizer coal-hoppers which are located on the operating floor directly above the pulverizers, have sufficient capacity to supply the pulverizers for about one hour under maximum demand conditions.

Figure 6 is an interior view of the boiler room on the operating floor level and shows many details of the larry.

Ash Handling and Storage

For the removal of ashes, a 6-in. steam-jet conveyor located back of the boilers is provided. Ashes are shoveled out of the furnaces by hand and then shoveled into the conveyor and delivered to the ash bunker. The ash bunker is of cast-iron plate construction and is completely closed except for a vent pipe which is carried through the roof of the building.

Boilers

Four boilers are installed consisting of two 500-hp. and two 340-hp. nominal rating. The larger boilers are Henry Vogt Machine Co. three-drum, bent tube, Class R, set in battery, and the smaller boilers are Babcock & Wilcox Co. longitudinal drum, straight tube type, set singly. All boilers are equipped with soot blowers and superheaters. The latter are designed to give 100 deg. F. superheat to steam at 200 per cent boiler rating. All boilers will operate at a pressure of 200 lb. per sq. in.

All furnaces are of air-cooled refractory-block construction in the high-temperature zone and of the usual solid firebrick construction in the low-temperature zones. The air-cooled blocks are of Furnace Economy Co. design. The blocks are held in alinement by numerous anchors which are attached to the furnace steel framework. The air-cooled sections of the furnaces are encased in sheet steel, with rock-wool heat insulation between the casing and refractory blocks. The solid masonry sections of the furnaces are insulated by means of a course of insulating brick between the inner course of firebrick and the outer course of common brick.

All furnaces were designed for operation at 200 per cent boiler rating. The larger furnaces have a volume of 3600 cu. ft. each and the smaller furnaces have a

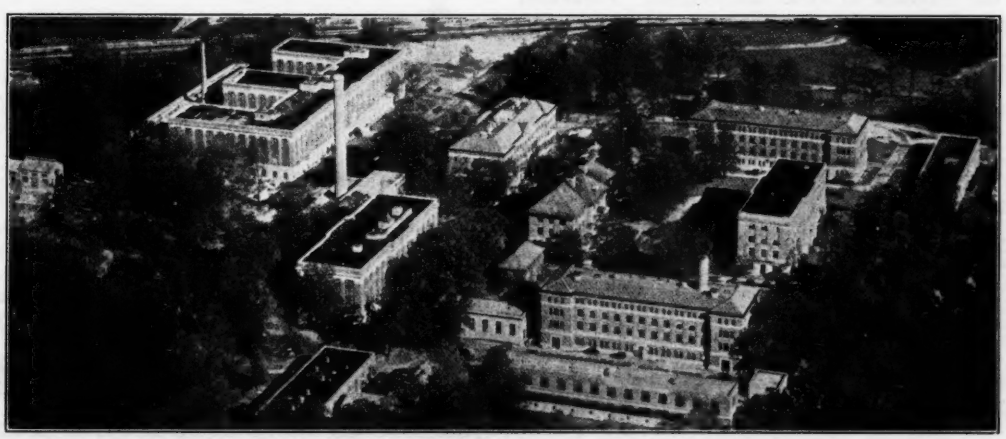


FIG. 1. THIS GROUP OF BUILDINGS IS SERVED BY THE NEW BUREAU OF STANDARDS POWER PLANT

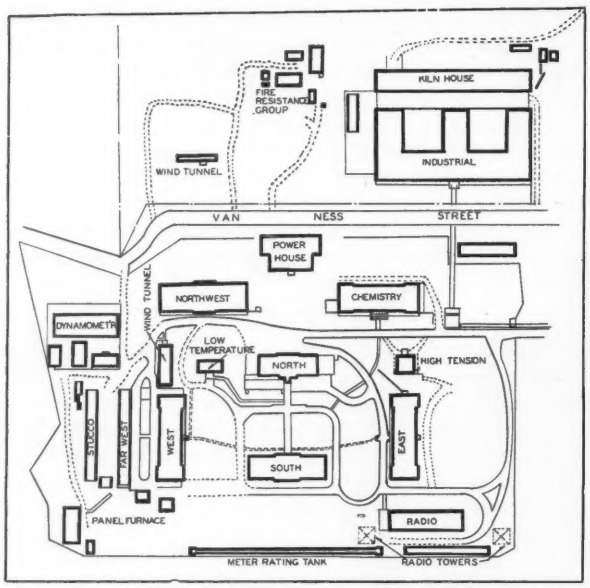


FIG. 2. PLOT OF GROUNDS SHOWING LOCATIONS OF BUREAU OF STANDARDS BUILDINGS

volume of 2435 cu. ft. each. This gives a heat release of 11,800 B.t.u. per hr. per cubic foot of furnace volume in each case when the boilers are operated at 200 per cent rating. Due to this comparatively low heat release per unit volume of furnace, no trouble should be experienced with an all-refractory furnace wall. No water-cooled walls were used excepting in the larger furnaces. Here an 8-ft. by 11-ft. Walsh & Weidner water-cooled section was used on each of the rear or bridge walls, due to the fact that there was danger of the flame impinging on these walls when operating at high ratings.

Pulverizers

For each furnace a Strong-Scott unit pulverizer is provided. The larger machines have a capacity of 3500 lb. of coal per hour and the smaller units have a capacity of 2000 lb. of coal per hour. Each mill is direct-connected to an induction motor which runs at 1750 r.p.m. No cross connection of pulverized fuel piping between the various mills and furnaces is employed, as the reliability of the pulverizers is thought to be such as to warrant the omission of cross connections. Preheated air for the pulverizers is taken from the air-cooled walls of the furnaces without the use of auxiliary blowers.

Figure 7 is an interior view of the boiler room at the basement level and shows clearly the arrangement of the pulverizer piping.

One radial brick chimney, 200 ft. high by 10 ft. inside diameter at the top, serves the entire plant.

Combustion Control

Automatic control of the rate of combustion necessary to maintain a constant steam pressure (200 lb. per sq. in.) is accomplished by Carrick regulators. A mercury float chamber which is connected to the steam main, operates a master regulator which in turn operates secondary regulators, one of which is located at each pulverizer. The secondary regulator is connected directly to the pulverizer coal-feed mechanism and air-control damper and operates to increase or decrease the rate of combustion as the steam pressure in the main decreases or increases. The ratio of fuel to air is established manually and is thereafter maintained automatically by the regulator.

A Carrick furnace pressure-regulator which operates independently of the combustion-control master regulator, is installed on each furnace to maintain the proper furnace pressure by the regulation of the furnace damper.

Feedwater Heating and Treatment

For heating the boiler feedwater, a single Cochrane deaerating, metering heater, open type, having a capacity of 110,000 lb. of water per hour is provided. The heater takes exhaust steam from the plant's steam-driven auxiliaries.

Softening of make-up water is accomplished by a single-unit water softener of the zeolite type having a capacity of 25,000 gal. in 8 hr. The plant operating schedule is such that there is ample time for regenerating the zeolite while the boilers are not in operation. Space was left in the heater room for the installation of a second water-softening unit should it be found desirable due to a change in the operating schedule.

Boiler feedwater is supplied by two Moore Steam Turbine Corp. turbine-driven pumps having capacities of 150 and 300 gal. per min. These pumps are located on the boiler-room basement-floor level, directly under the feedwater heater thus giving a positive head of approximately 13 ft. on the pump inlet.

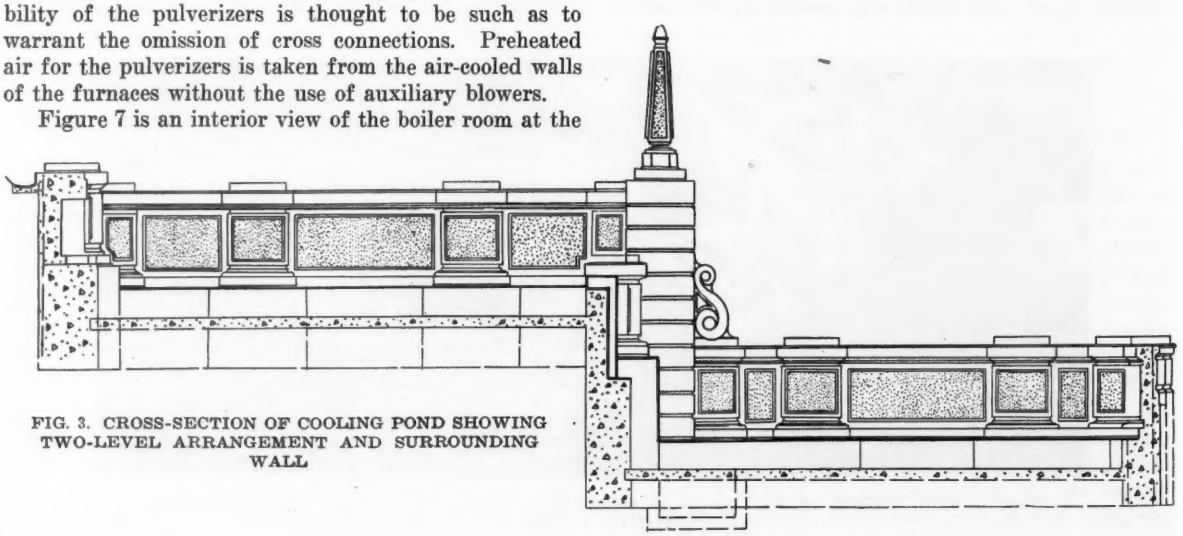


FIG. 3. CROSS-SECTION OF COOLING POND SHOWING TWO-LEVEL ARRANGEMENT AND SURROUNDING WALL

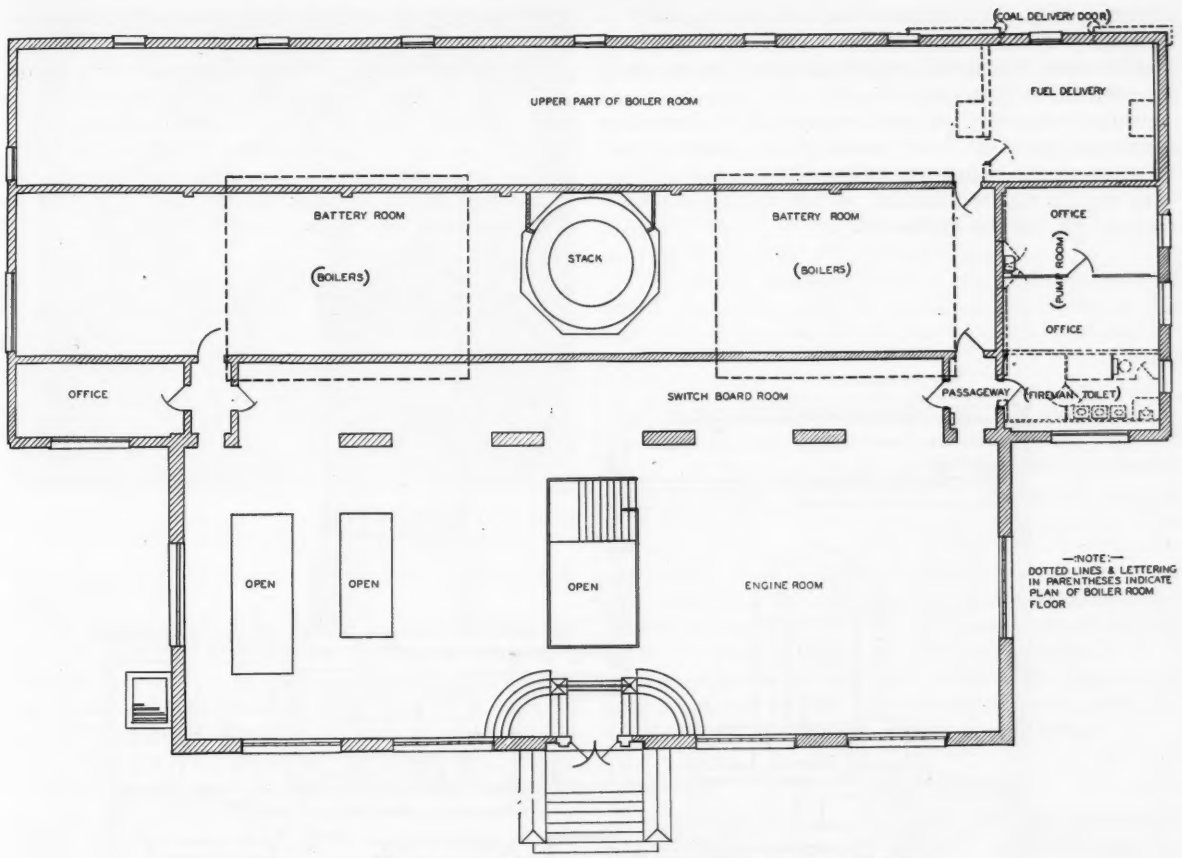


FIG. 4. PLAN OF POWER PLANT AT ENGINE ROOM FLOOR LEVEL

All of the boiler-room instruments will be mounted on the board shown in the center of Fig. 7. The instruments will consist of CO_2 recorders, pyrometers, steam-flow meters, recording pressure gages, draft gages, clock, etc. The CO_2 and steam-flow meters are electrically operated. All clocks used in instruments are synchronous motor-driven.

All Piping Is Welded

All feedwater, blowdown and steam piping is gas welded. Genuine wrought-iron extra-heavy pipe was used in the water lines and standard weight steel pipe was used in the steam lines. No fittings of any description were used and flanged connections were used only where it was necessary to insert valves and orifice plates. Where cast-steel elbows are required ordinarily, welded-in tube turns were used instead. By using welded connections, the weight of the piping installation was greatly reduced and the installation of the pipe covering greatly simplified.

Power is generated by a unit consisting of a Murray Iron Works Co. turbine, direct connected to an Allis-

Principal Equipment in Bureau of Standards Power Plant

Boilers and Auxiliaries

Boilers: 2—500-hp. bent tube, Class R .....Henry Vogt Machine Co.
2—340-hp. longitudinal drum.....Babcock & Wilcox Co.
Water Walls: 2—Cast armoured tube .....Hedges-Walsh-Weidner Co.
Furnaces: 4—Air-cooled refractory blocks.....Furnace Economy Co.
Superheaters: 4—Elesco.....The Superheater Co.
Feedwater Regulators: 4—Copes.....Northern Equipment Co.
Soot Blowers: 18—Valve-in-head.....The Bayer Co.
Steam Flow Meters: 4—Electric recording-integrating .....Brown Instrument Co.
CO_2 Recorders: 2—Electric recording.....Brown Instrument Co.
Stack: 1—200 ft. by 10 ft. radial brick.....M. W. Kellogg Co.
Breeching: Steel, bellows type.....Connery & Co.
Feed Pumps: 1—150-gal. turbine-driven, centrifugal .....Moore Steam Turbine Corp.
1—300-gal. turbine-driven, centrifugal..Moore Steam Turbine Corp.
Feed Heater: 1—110,000-lb. deaerating, metering..Cochrane Corporation
Water Softener: 1—25,000-gal. zeolite type.....Permutit Co.

Coal and Ash Handling

Coal Bunker: 1—400-ton steel-plate .....Wilbur G. Hudson Corp.
Coal Conveyor: 1—Peck carrier, pivoted bucket.....Link-Belt Co.
Pulverizers: 2—3500-lb. unit pulverizers.....Strong-Scott Mfg. Co.
2—2500-lb. unit pulverizers.....Strong-Scott Mfg. Co.
Ash Conveyor: 1—6-in. cast pipe, steam jet .....The Frederick Iron & Steel Co.
Ash Bunker: 1—20 ton, cast iron.....The Frederick Iron & Steel Co.
Automatic Scale: 1—400 lb.....Richardson Scale Co.

Piping and Valves

Piping: All welded.Heat & Power Corp.
Valves: All steel.....Crane Co.
Non-return Valves: 6 and 8 in.....Golden-Anderson Valve Specialty Co.

Generating and Electric Equipment

Turbine: 1—750 kw., extraction type .....Murray Iron Works Co.
Generator: 1—750 kw., 3 ph., 60 cy., 2300 v.....Allis-Chalmers Mfg. Co.
Exciter: 1—12 kw., motor-driven.....Westinghouse Elec. & Mfg. Co.
Condenser: 1—Surface type, 1250 sq. ft.....Elliott Co.
Circulating Pump: 1—Turbine-driven, centrifugal.....Dayton-Dowd Co.
Condensate: 1—Motor-driven, centrifugal .....Elliott Co.
Air Ejector: 1—6.5 cu. ft. per min. .....Elliott Co.
Spray Pond Equipment: 56—Spray heads and piping..Spray Eng'r'g. Co.
Switchboards and Switches.....Westinghouse Elec. & Mfg. Co.
Outside Substation Structure.....Westinghouse Elec. & Mfg. Co.
Outside Substation Transformers.....American Brown Boveri Co., Inc.

Chalmers Mfg. Co. generator rated at 750 kw., 2300 v., 3 phase, 60 cycles. The turbine is of the automatic extraction type which will supply extracted steam at 10 lb. gage for heating purposes.

Only one generating unit is installed at present as connection with the local public utility company will be retained for supplying night, Sunday and holiday load and to supply stand-by service in case of breakdown of the bureau equipment.

for supplying closely-regulated power of various voltages and frequencies for special work.

An Elliott 1250-sq. ft. surface condenser to operate at 27.5 in. of vacuum is installed in connection with the main turbine. The circulating water pump is turbine-driven. A separate motor-driven pump is provided to return the condensate to the feedwater heater. One single-stage steam-jet pump is provided to remove air and noncondensible vapors from the condenser.

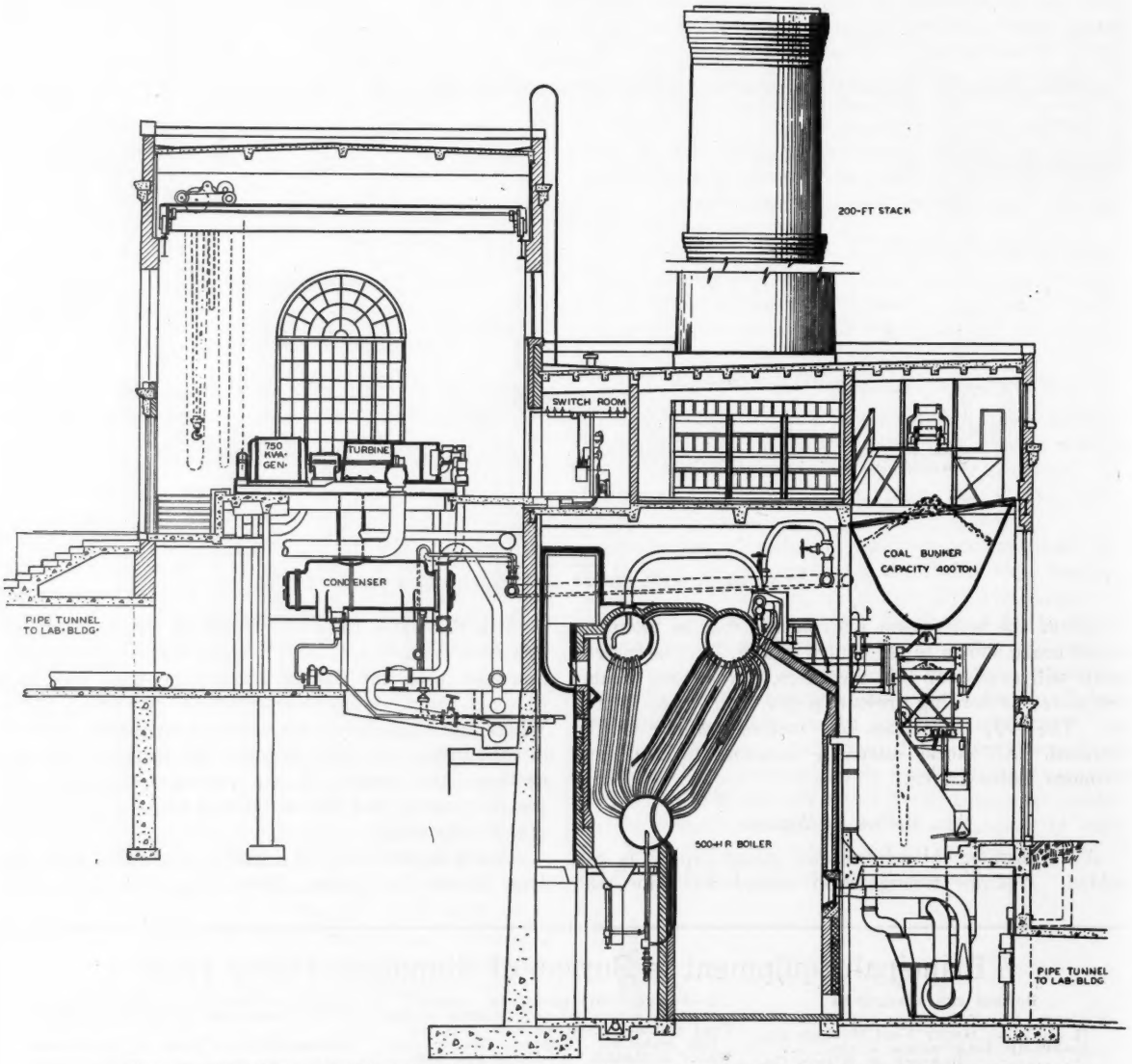


FIG. 5. GENERAL ARRANGEMENT OF EQUIPMENT IS SHOWN IN THIS CROSS-SECTION

Two sources of power supply are very desirable, due to the nature of the work carried on at the bureau. Many of the investigations in connection with research projects, extend over long periods of time and a failure of the power supply for a short time may cause the loss of much time and valuable material.

The principal direct-current supply at 110—220 v. is taken from a 500-kw. synchronous converter which in turn takes its supply from either the bureau's turbo-generator or the power company's bus.

Numerous small motor-generator sets are provided

Circulating water is cooled in a spray pond previously mentioned. This pond, as now constructed, has sufficient capacity to handle double the quantity of water needed at present and provision is made in the pond design for adding another pond unit at some future date.

Switching Arrangement

As previously pointed out, all generator and feeder panels are set flush with the engine-room wall and form one side of the switch room. All buses, oil switches and

FIG. 6. DELIVERY OF COAL TO PULVERIZERS IS HANDLED FROM BOILER ROOM OPERATING FLOOR LEVEL

switch-operating mechanism are located in the switch room.

Two 3-phase, 2300-v. buses are provided, one for the bureau's generator and one for the power company's incoming supply. Switching arrangements are such that these buses may be operated separately or in parallel and that any feeder may be switched from one source of supply to the other at the will of the operator. Power is taken from the power company's 13,200-v. transmission line and stepped down to 2300 v. through three 250-kw. transformers which are located outside of the building.

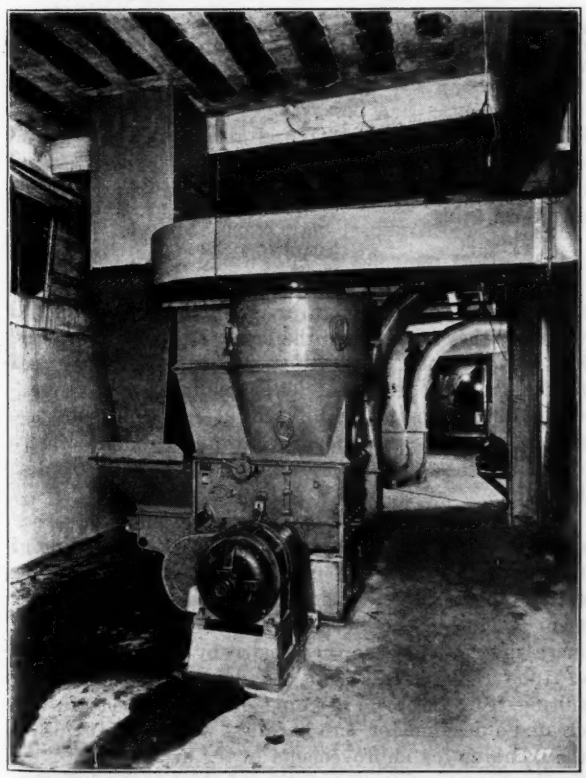


FIG. 7. UNIT PULVERIZERS LOCATED IN THE BOILER ROOM BASEMENT

Storage batteries are provided to meet the requirements for extremely constant potential and current required in many types of tests and research work. These batteries range in size from 5 to 55 amp., 8 hr. discharge rate. Sixty cells, giving a terminal potential of approximately 120 v., are provided in all cases with inter-cell taps for lower voltages where required.

All batteries will be located in the battery room shown in Fig. 4, which has sufficient space for approximately 30 complete 60-cell batteries.

All battery terminals are brought out to a plug-type board where they may be connected to any one of the many trunk lines leading to the various laboratories.

Refrigeration

A central refrigerating plant will be installed in the basement of the engine room at some future date, to supply refrigeration to the various laboratories requiring this service. It is proposed to use the CO_2 system of refrigeration in two stages of compression. This system is proposed due to the fact that much of the experimental work requires temperatures below those obtainable with the ammonia system and that the transmission piping system is comparatively simple and involves no great personal or property hazards.

Air compressors, high and low-pressure pumps and vacuum pumps will be installed in the power plant for supplying the air services needed by the bureau.

Why Mail Is Lost

THE MOVING SEASON is again with us. More than half a million changes of address were filed with the Chicago Post Office during the past year, according to Postmaster Arthur C. Lueder, but there were many thousands who moved who did not notify the post office, with the result that many pieces of first-class mail and parcel post remained undelivered and great quantities of circular matter and newspapers were returned or destroyed.

If you move, notify the post office, GIVING THE OLD AND NEW ADDRESSES. Blanks for this purpose may be obtained from the carrier, or an ordinary post card or letter may be used.

Subscribers to newspapers and magazines should immediately notify the publisher of a change of address so that they may continue to receive their publications without interruption. The old, as well as the new, address should be furnished in every instance.

CASH AWARD of $50 and a certificate to the plant where the writer of the article is employed, are offered by the National Industrial Equipment Exposition for the best suggestion or idea for waste elimination. Suggestions should be sent to 308 West Washington St., Chicago, and should be in the hands of the Award Committee by May 30. Any company may send in three suggestions from different employes, each article to be not more than 300 words. Committee to decide on the winner consists of James D. Cunningham, president, Republic Flow Meters Co.; C. D. Auel, Westinghouse Electric & Manufacturing Co.; John Commody, Factory and Industrial Management.

INSTRUMENTS which cannot be calibrated or compared occasionally with standards should be avoided.

Boiler Feedwater Purification Methods

Discussion of Impurities Commonly Found in Water, Troubles Resulting from Their Presence and Methods of Removal. By H. A. Kuljian.* Part I

RAW WATER, such as we use in our daily life, was once vapor. When this vapor condensed, it came down to the earth as rain and formed rivers, lakes and oceans. Heat from the sun is continuously evaporating the water on the surface of the earth and the cycle is repeated. After condensation takes place, the drops filter through the air absorbing oxygen and other gases in the air so that by the time they hit the ground, they are saturated with dissolved oxygen. Approximate saturation curve of oxygen in the air at different temperatures is shown in Fig. 1.

After falling on the earth as rain, this water flowing in streams will sweep the surface of rocks and will pick up and hold in mechanical suspension such particles of organic matter as, clay, sand, iron and alumina and often sewage and industrial wastes. It continues its way dissolving salts of calcium, magnesium and sodium, in various forms such as carbonates, bicarbonates, sulphates, chlorides and nitrates. Gases present may assist in the dissolving, combine with newly procured salts, or remain in excess as conditions determine.

For reference and discussion, the principal impurities may be classified as follows:

1. Suspended matter.
   - A. Inorganic or mineral
     - a. Sand and clay
     - b. Iron and alumina
   - B. Organic
     - a. Living organisms
     - b. Animal matter
     - c. Sewage
     - d. Oil
   - C. Vegetable
2. Dissolved matter.
   - A. Gases
     - a. Oxygen
     - b. Nitrogen
     - c. Carbon dioxide
     - d. Hydrogen sulphide
   - B. Solids
     - a. Salts of calcium and magnesium
     - b. Salts of sodium and potassium
     - c. Organic and inorganic iron
     - d. Manganese and aluminum salts
     - e. Organic compounds
     - f. Vegetable

With rare exceptions, water supplies as they occur in nature contain impurities, which are harmful for boiler operation and so require proper treatment before they are used as feedwater. Otherwise, these impurities may cause corrosion and pitting of metal surfaces, scaling of boiler drum as well as tubes, foaming and priming within boilers and so-called embrittlement of boilers.

*Engineer in charge of Power Division, The Viscose Co., Marcus Hook, Pa.

If water is chemically pure and free of any gas like carbon dioxide (CO_2) and oxygen in solution, it has practically no effect on the boiler metal. Such a condition is almost impossible to attain unless some method is used for freeing the water of CO_2 and free oxygen. If water is let into a boiler without the removal of CO_2 or oxygen, the inner surface of the boiler metal will begin to show slow oxidation.

Corrosion is also caused by the presence of free acids

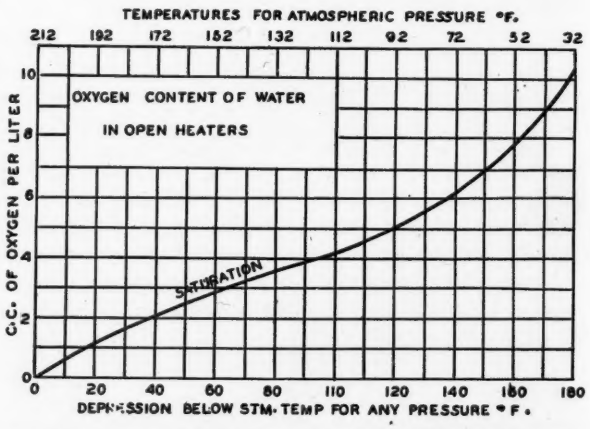

TEMPERATURES FOR ATMOSPHERIC PRESSURE °F.
212 192 172 152 132 112 92 72 52 32
OXYGEN CONTENT OF WATER
IN OPEN HEATERS
SATURATION
C.C. OF OXYGEN PER LITER
0 2 4 6 8 10
0 20 40 60 80 110 120 140 160 180
DEPRESSION BELOW STM. TEMP FOR ANY PRESSURE °F.

FIG. 1. CURVE SHOWING THE ABSORPTION OF OXYGEN IN FRESH WATER AT ATMOSPHERIC PRESSURE AND VARIOUS TEMPERATURES (USE TOP TEMPERATURE SCALE)

like H_2SO_4, HCl and HNO_3 and also by the presence of organic material such as infusion of leaves, sewage, chlorides and sulphates of magnesium which decompose and form acids.

Scaling

Scaling is due to an accumulation of insoluble solids in the boiler. They stick to inner surface of boilers and the more they accumulate the more they will reduce the heat conductivity of the tubes, causing blistering and finally the loss of tubes. This condition may be prevented by removing such harmful insoluble salts, by means of frequently blowing down the boiler, or by replacing these insoluble salts by ones that are less harmful.

These impurities not only decrease boiler efficiency and waste fuel but frequently cause local overheating of the tubes or drums and frequent boiler shutdowns for costly repairs and cleaning. This means an idle investment. The high cost of labor for cleaning boilers, the increasing value of the fuel wasted by the scale, the cost of tube replacements and the damage frequently resulting from the scale cleaning operation has naturally created a demand for zero hardness water and furnished the stimulus for improvements in the art of water purification to provide feedwater of higher and higher quality.

It is sometimes claimed that a feedwater containing as much as 2 to 5 gr. per gal. of hardness does not form a sufficient deposit in boilers to warrant consideration. Practical experience, however, proves that such a water is not satisfactory for boiler feed purposes.

Today, the tendency towards boilers of ever-increasing size operating with automatic stokers, powdered coal or oil, at 200 to 400 per cent of normal rating and at high pressures and superheat, has developed an entirely new set of conditions. Such boilers cannot be thrown off the line for repairs with the ease of former days. They are expected to run continuously for considerable periods without shutdown. What was good enough 10 yr. ago with small boilers at low ratings, low pressures and low efficiency can no longer be countenanced. A water containing 5 to 6 gr. per gal. of hardness in a 1000-hp. boiler running at 300 per cent rating deposits in one day 220 lb. of scale matter on the inside of the boiler in 10 da. more than 1 t. This certainly is not good enough. The limit of hardness in the feedwater must obviously come down to zero.

Foaming and priming are largely due to the presence of suspended inorganic, organic, matter and oil. They get in the boiler drum and collect on the top of water in the drum and prevent free liberation of steam. As a result priming takes place. This is reduced by making use of a surface blowoff on a boiler drum, or by filtering the water for the removal of suspended matter and oil before it is sent to the purification system.

Embrittlement is due to accumulation of sodium hydroxide (NaOH) in the boilers where the plate has been stressed beyond the yield point. As they concentrate they will attack the boiler plate or metal and cause embrittlement. This ordinarily takes place in the boiler drum below the water level. It can generally be detected if microscopic analysis is made on the boiler between the rivet holes on the outside of the boiler drum where they are being calked. The question of embrittlement of boiler plates is discussed and explained very thoroughly by Professors Frederick A. Straub and Samuel A. Parr of the University of Illinois. (See Power Plant Engineering, Feb. 1, 1929, p. 173.)

Methods of Water Purification

Various methods of water purification in use today may be classified as follows:

1. Removal of suspended matter by
   - A. Settling
   - B. Coagulation and settling
   - C. Filtration
2. Removal of dissolved matter
   - A. Gases
     - a. Aeration
     - b. Deaeration
     - c. Heating
   - 2. Dissolved solids
     - a. Distillation
     - b. Treatment by soluble reagents
     - c. Contact with the insoluble reagent (zeolite water softening system)

Sedimentation alone is effective only for the removal of heavy particles like sand or mud. For finely divided turbidity, color or organic matter, it is best to employ some coagulant such as alum sulphate, sodium aluminate, or iron sulphate, to form a flocculent precipitate (floc) that enmeshes these smaller particles in its midst to hasten or permit removal by settling or filtration. Filtration alone, following the application of a coagulant, is used for waters that are only slightly turbid. But in the case of high turbidity filters should be preceded by a well designed settling tank in which most of the floc with its enmeshed mud, can settle out.

Removal of suspended matter alone does not as a rule insure clean boilers. There are many clear well waters which form heavy boiler deposits and cause serious difficulty. Dissolved matter, both gaseous and solid, must also be removed if they are present.

Removal of Dissolved Gases

Gases, dissolved in water, offend by causing objectionable tastes and odors for potable purposes, by causing corrosion for industrial purposes. Malodorous gases like hydrogen sulphide (H_2S) can best be removed by aeration, scrubbing the objectionable gas out by trickling the water through an atmosphere free from that gas. This, of course, saturates the water with oxygen which must later be removed.

To remove CO_2 and oxygen, for boiler feed purposes, where hot water is required, the heating by direct contact with steam is the simplest method. As long as such mixing or contact heaters are properly vented to remove the liberated gases and sufficient steam is employed to raise the temperature of the heated water always to the boiling point, the gases are removed sufficiently to protect boilers against corrosion. To protect steel tube economizers, a more perfect gas removal is necessary and special means are provided by deaerating heaters.

Distillation accomplishes water purification by evaporation and condensation. The vapor, as it forms, leaves behind most of the impurities present in the feedwater. Care must be taken that the evaporators are blown down sufficiently and that they are not overloaded so that the vapor does not entrain too much of the salines. Condenser leakage, whereby the hard cooling water leaks into the condensate also is a source of contamination of the water so that even an evaporator installation does not necessarily keep boilers clean.

Sea water contains a strong solution of sodium, lime and magnesium salts, therefore the only way of preparing pure water is to install evaporators and then condense it for boiler feed makeup. In public utility stations the quantity of makeup is small percentage of steam generation. Evaporating equipment there fits in nicely as a portion of the condensate from the main condenser can be used as circulating water to absorb heat from the evaporator vapor and save it. A good water is obtained nearly free from all chemical impurities, although great care must be taken in deaerating such water before it is picked up by the feed pumps.

When it comes to industrial boiler feed makeup, the proposition is altogether different. There are industries where the makeup is from 30 to 100 per cent. Evaporating equipment for makeup can never be considered, on account of space requirements, initial cost, yearly repairs and maintenance.

Most industrial plants, therefore, purify their water by other methods, such as treatment with soluble reagents or with the insoluble reagent zeolite. Soluble reagent treatment which is frequently called precipitation methods may be external to the boiler or internal.

Spare Machine Parts Pay Dividends

By Marin Phillips

IN INDUSTRIAL plants, the value of spare parts for equipment and machinery cannot be accurately computed in dollars and cents, as is the case in many other plant expenditures. With this thought in mind, there is a tendency for some plant executives, and others as well, to look upon the spare part stores as an expensive and unwarranted collection.

This is the day of production and the cry "production comes first" is ever before us. So it is necessary to keep the wheels of industry turning to grind out this production. In other words, machinery delays will not be tolerated.

Breakdowns of machinery just naturally have a way of happening, even in the best maintained plants, regardless of whatever the maintenance policy or inspection routine may be. If it were not for this fact and the fact that an impending breakdown does not always give any warning beforehand, the repair part stores could, in most cases, be materially reduced; but as this is not the case, it becomes necessary to carry certain parts whereby the repair of these sudden and unexpected breakdowns can be rushed to completion with the greatest of haste, and with the least possible time lost for the machine.

Spare Parts Are Like Insurance

Spare parts are a financial necessity. They are the insurance on the operating equipment. Most of us carry insurance on our life, car, house and furniture, and look upon it as a necessity, even though we may never realize anything from it. Factories, also, carry insurance on the buildings and on some types of machinery as a protection against losses. Then why should not the necessary repair parts be looked upon as a form of insurance and a necessary expenditure?

Most of us, I am sure, have gone through one or more of these breakdowns without having the necessary parts with which to make the repair, all because some one had decided that the repair part was not needed as a spare part. And the sad part of it was that the purchasing agent spent more money for telegrams, telephone conversations, parcel post and other services to get quick action than the article cost, to say nothing of the delay and inconveniences while procuring the article or trying to make it.

Home-Made Repair Parts Are Expensive

Repair part stores should not be looked upon as simply a means of rushing a breakdown repair to a quick finish. These stores are valuable in another way that is often overlooked. We have often seen a workman who was earning a dollar an hour, or more, on Sunday making repairs on some machine without having the spare parts with which to do the job and has to fashion some spare part the best way he can. Quite often it will be the making of a small spring that would cost, probably, 10 or 15 cents to purchase from the manufacturer and the workman will spend an hour or more, sometimes, making and adjusting the spring and after the job is completed it will not be as good a job as it would have been had the right spring been on hand that could have been slipped into place in a few minutes at a great saving in labor cost.

These tinkering repairs are often made while a machine is down and holding up production. Just the old standing proverb "penny wise and pound foolish." As an example of how far some of those responsible for the plant maintenance will practice this is borne out in the following case. A certain plant engineer was so bent on saving that he could only see one thing, that is, buy nothing. This was so imbedded in his mind that he overlooked the chances for saving through the purchase of supplies that he could buy far cheaper than he could possibly hope to make them, and what is more, they would give him better services. He would keep a workman at 60 cents an hour making attachment plugs for extension cords out of broom handles and burned out lamp bases.

Another pet hobby of this engineer was the making of his own generator and exciter brushes. He would purchase carbon blocks from which the brushes would be cut and filed down to fit. The "pig tails" or shunts were made out of old flexible wire with a terminal soldered on each end and one end was attached to the brush with a small machine screw. He had more grief and plant shutdowns due to an interruption of power than from any other cause. The cost of one shutdown would have kept him in manufactured generator brushes for more than the life of the machines. There was grief because the brushes were not suitable for the machines, as well as their sticking in the holders and the machine screws working loose.

I do not advocate the purchase and accumulation of a lot of unnecessary repair parts. And most assuredly, the man responsible for the purchasing of repair parts should use common sense and good judgment when making these purchases. Then, too, he should weigh all of the evidence when he is considering the making of his own repair parts to see whether he can compete with the manufacturer. In most cases, he can not do it successfully. He may be a good mechanic, but has he the materials that have been proven by test to be the best for the part in question, from which to make the parts? And a big item is, has he the tools and equipment with which to do the work? Will it pay him to provide these facilities for the number of parts that he will want to make?

Choice of Repair Parts

It is not a hard problem to provide the necessary repair parts that wear out frequently. The big problem is to be able to foresee what spare parts to carry which do not often wear out. Experience is the best guide that any one can have on this vital question. After it is finally decided what repair parts to carry in stock, the number of items will depend on how many are needed to make a repair, the number of machines in operation and the frequency with which they have to be repaired, also how long it takes to get the repair parts when ordered.

It is easy to spend the other fellow's money and this thought should be kept in mind when purchasing spare parts, but not to the extent of penury. Repair parts can certainly be made to earn their keep. Yes, and pay dividends, that are hard to estimate in dollars and cents if due caution and good judgment are exercised in their purchase.

A new

OPERATING CODE MANUAL

for Power Plant Engineers

RULES COVERING THE OPERATING PROCEDURE OF ALL TYPES OF PLANTS CAN SERVE AS A BASIS OF SPECIFIC CODE FOR INDIVIDUAL PLANTS

APPARENT NEED for an operating manual of this type, outlining rules of operating procedure in both the boiler and turbine rooms of steam-generating plants, has led the Prime Movers Committee of the N. E. L. A. to revise and republish in convenient form all of the previous reports of the Subcommittee on Operating Code Manual. Rules contained in previous reports were based on the comments and criticisms to questions contained in questionnaires drafted from rules extracted from the Station Operating Handbook of the Philadelphia Electric Co.

As it is impossible to formulate one set of rules to fit all cases, no attempt is made to stress adherence to the sequence of the different operations; it is understood that modifications are necessary, depending upon the best judgment of the particular problems and upon the installed equipment in each individual plant.

Use to which an operating code may be placed lies entirely in the hands of the individual engineers. It is probable that in emergency cases such rules will of necessity be overstepped or entirely ignored but their very existence and the familiarity of the operator with them for normal operation will cause them to serve as a guide and promote good judgment in cases of emergencies.

Value of a code of this kind is not measured by the exactness with which the rules embodied are carried out, but rests, rather, upon the fact that these rules in their general make-up include all possible necessary phases of any particular operation.

General operation, routine, care and maintenance of all equipment in the modern boiler and turbine room is covered in two sections. The first deals with boilers, coal handling equipment, pulverized coal auxiliaries, fans, boiler feed pumps, feedwater heater and evaporators; the second with turbines, reciprocating engines and all auxiliaries. The operating code will be published in full in sections, this part dealing with turbines being the first part of the series.

INSPECTION BEFORE TAKING OVER SHIFT

1. The engineer coming on must receive a report covering all matters pertaining to the operating conditions of all apparatus from the retiring engineer.

2. The engineer must verify this report by personal inspection of all apparatus.

3. The engineer must see that he has sufficient force on hand to operate his shift before the men on the previous shift are allowed to leave.

4. The engineer should see that sufficient apparatus is available for expected load.

5. The engineer or instrument man must take all meter readings and change all charts on the (....) shift. The engineer shall verify the design and date on all charts before their removal.

PROCEDURE BEFORE STARTING

1. Notify boiler room as to steam requirements.

2. Remove all bolts, tools, etc., which may have been left on or near the machine and if any repairs have been made while machine was down, examine position of all valves on entire unit.

3. Make a general inspection to see that the machine and auxiliaries are in proper condition for operation and that duplicate auxiliaries (where provided) are in readiness for emergency use.

4. When a gravity lubricating system is used, see that sufficient oil is in the system and that oil in proper quantities is being supplied to all bearings.

STARTING TURBINES

1. Notify switchboard operator that machine is ready to be warmed up.

2. After receiving the affirmative reply, start the auxiliary oil pump and see that it is operating under correct pressure.

3. Start the circulating pump and air pump, giving proper attention to the priming of the circulating pump and the removing of air from the water side of condenser.

4. See that oil is circulating to all main bearings and check oil filter operation.

5. See that governor is being supplied with oil.

6. Rule to cover any trying out of speed control mechanisms while machine is stationary should be made by the constituted authority and inserted here.

7. Examine all gages and see that steam gages show proper pressure; vacuum gages show proper vacuum and oil and water gages show proper pressure.

8. Start the hotwell pump. (Note: Hotwell pump should be started when high water alarm signal operates, with discharge throttled to hold proper level of water above pump while warming up the turbine.)

9. Turn on steam to turbine seals. (Note: Steam should be applied to seals just before starting up, so that no stresses will be set up by localized heating of stationary shaft.)

10. See that all turbine drains are open. (Note: Open drains when same will not seriously interfere with vacuum. In case draining and sealing are effected through the same line, rule to cover specific practice and equipment should be made by the constituted authority and inserted here.)

11. Open the throttle quickly until the first stage pressure gage registers (....) lb.

12. As soon as the spindle starts rolling, close the throttle to point when machine's speed is at desired rate for warming up the unit. (Note: Vacuum during warming up process to be such that temperature through low pressure portion of turbine will approximate temperature of operating conditions.)

13. If specific practice is to trip the throttle during starting up operations, rule to cover this feature should be made by the constituted authority and inserted here. (Note: It is recommended that this rule be related to the above rules No. 11 and 12, so that tripping is effected when the valve has a small opening, as it is most conducive to sticking at this time.)

14. Listen for internal rubbing until turbine goes into service.

15. With spindle revolving, turn on water to water seals.

16. Turn on cooling water to oil cooler and main bearings. (Note: Water valve to oil cooler should be cracked slightly after turbine is started to keep water circulating through cooler to prevent a sudden change of temperature in cooler. A close watch on oil temperatures will determine further regulations to oil cooler circulating water, and the time to turn on cooling water to main bearings.)

17. When unit is warmed up, notify switchboard operator that machine is ready for operating speed.

18. After receiving affirmative reply, open the throttle until the first stage pressure registers (....) lb., and maintain this pressure until the machine comes up to speed, which will be indicated by the closing of the admission valves by the governor and a reduction of the first stage pressure below normal starting pressure.

18-a. If the machine is equipped with an oil pump operated off the turbine shaft, see that this pump goes into service as the machine comes up to speed and that the auxiliary oil pump slows down to a very slow, but continuous, speed.

18-b. As the machine comes up to speed, watch for vibration and do not operate on critical speeds longer than necessary. (Note: This rule to be made specific by the constituted authority, in accordance with turbine manufacturers' node data.)

19. Open the thottle wide, noting that no increase takes place in the first stage pressure or in the turbine speed as shown by the speed indicator.

20. Close the throttle valve until it is sufficiently in advance of the governor to carry the synchronizing load.

21. Notify the switchboard operator that the machine is ready for "load."

22. After receiving affirmative reply, synchronize the machine as quickly as possible and apply load up to (....) kw.

23. See that vacuum is at a maximum.

24. Build up load on the machine at the rate of approximately (....) kw. per min. (Note: As the load comes on, the opening of the throttle valve should be gradually increased and kept in advance of the governor.)

25. When machine is carrying approximately (....) kw., open the throttle wide and regulate the amount of steam supplied to the seals.

26. Make general inspection of all gages and oil temperatures from all bearings.

Shutting Down Turbines

1. After being notified by the switchboard operator that load is to be taken off the machine, stand by to regulate the sealing system as the load decreases.

2. Start the auxiliary oil pump by hand, to see that it will start properly.

3. After being notified by the switchboard operator to "stop" the machine, close the throttle slowly. (Note: If the specific practice is to close the throttle with hand trip or oil relay while shutting down, rule to cover this operation should be made by the constituted authority and inserted here.)

4. See that the auxiliary oil pump starts as the machine slows down, and that proper pressure is maintained.

5. Break vacuum when machine is approximately (....) per cent below operating speed.

6. Shut off steam and water to seals, and open drains to see that valves are not leaking. (Note: Do not shut off all the steam to seals until vacuum is destroyed because of the harmful effect resulting from cold air being drawn through the seal glands.)

7. After machine stops, shut off the oil and water supply to the main bearings and oil cooler. (Note: Temperatures will be a guide in shutting off the water to water cooled bearings.)

8. Shut down the auxiliary oil pump.

9. See that the admission valves have been opened by the governor.

10. Open atmospheric relief valve drains.

11. Make a general inspection of the turbine.

12. Check the exhaust casing temperature for steam leakage past the throttle valve.

13. Lubricate admission valves with a high grade cylinder oil and a small quantity of graphite.

14. When the condenser circulating pumps are shut down, note that the condenser low water alarms operate.

From Vienna it is reported that some important developments in high-pressure steam utilization are taking place at the Witkowitz iron and steel works and collieries in Austria, the company being at present engaged on the construction under license of a battery of Loeffler steam boilers intended for use in one of its own power generating stations. The boilers are being built for a working pressure of 1850 lb. per sq. in. and to provide steam at a temperature of 932 deg. F. for a 36,000-kw. three-stage steam turbine and alternator designed to run at 3000 r.p.m.

Construction work started last November and scheduled for completion August 1, 1931, on the Ariel project of the Northwestern Electric Co. on the Lewis River, is progressing rapidly. All roads for construction work about the project are complete and the cement plant, gravel plant and concrete plant in operation. The upstream cofferdams are more than three-quarters finished, the excavation on the side wings of the dam is nearing completion and the concrete work on the dam abutments will start about May 1. Excavation work on the diversion tunnel, 1460 ft. long with a 27-ft. bore, has been completed and the lining is now being placed.

Spindle Turning Gears for Steam Turbines

STARTING TIME OF LARGE TURBINES MORE THAN HALVED BY MOTOR-DRIVEN EQUIPMENT WHICH TURNS SPINDLE AT ABOUT 25 R.P.M. DURING WARMING UP PERIOD

STARTING CHARACTERISTICS of turbines constitute a subject of great importance because in stations taking peak loads and line swings, one or more units must be taken off the line at some period of the day but must obviously be held in readiness to take load again on short notice.

A turbine which is brought to rest after carrying load will, of necessity, be distorted during the cooling period because the hottest gases tend to go to the top of the cylinder and the coolest to the bottom, so that a considerable temperature differential is created between the uppermost and lowest parts of the rotor. This results in the development of an upward bow in the rotor and if started when in that condition it is bound to be out of balance and will cause vibration of a seriousness dependent on the degree of temporary unbalance.

To correct this condition or to minimize its effects, several devices have been employed by the Westinghouse Elec. & Mfg. Co. One means of securing approximately uniform cooling of the rotor consists of providing a number of nozzles at suitable points in the cylinder wall through which compressed air may be introduced. The air sets up an artificial and fairly uniform circulation of gases throughout the cylinder, thus greatly reducing the temperature differential.

A means of minimizing the effect of uneven cooling is to rotate the spindle at proper intervals through 180 deg. so as to expose opposite portions to the effect of the gases. For this purpose, an hydraulic jacking gear, Fig. 1, operated by high-pressure oil and controlled by a hand valve, is provided on present day large turbines.

A third device is a motor-operated turning gear, Fig. 2, by means of which the rotor may be kept revolving at about 25 r.p.m. throughout the cooling period. The turning gear may be engaged before the turbine comes to rest and is automatically disconnected in the event that the operator neglects to disengage it by hand. Usually the motor furnished is not sufficiently powerful to start the spindle from rest unless the bearing oil films are established. Hence, in conjunction with the turning gear, a source of high-pressure oil at about 1200-1400 lb. per sq. in. is provided and connected to special oil inlets in the bearings, as in Fig. 4, so that the journals may be raised out of contact with the bearing surfaces. The rotor may then be started with the jacking gear and the turning gear will then take up the work and keep it in rotation.

On the most recent turbines of large size, all three of these devices are supplied and by their aid the starting time has been more than halved.

Details of the oil operated jacking gears are shown by Fig. 1 with the mechanism installed in the turbine coupling housing. It consists essentially of an oil-operated piston A which carries a pawl B. This pawl engages the ratchet teeth which are machined on the coupling sleeve. As shown in the drawing, the piston is in its lower extreme position and the pawl is held out of engagement with the coupling teeth by reason of a projecting toe on the pawl being in contact with a stop lug on the cylinder. This, of course, is the normal position of the jacking gear while the turbine is in operation.

High-pressure oil (approximately 400 lb. per sq. in.) which is admitted to the bottom of the cylinder, moves the piston and pawl upward. As soon as the piston has moved a short distance, the projecting toe is released and the spring C forces the pawl to the right to engage

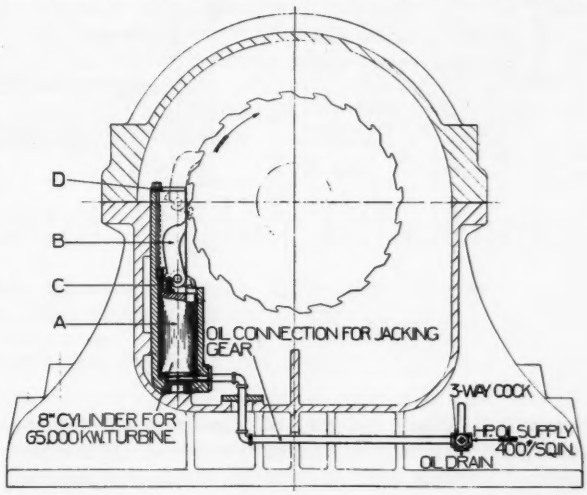


FIG. 1. OIL OPERATED SPINDLE JACKING GEAR

the ratchet teeth on the coupling. Further movement of the piston then rotates the turbine spindle.

The mechanism is manually operated by a three-way cock installed in the high-pressure oil supply line. The cock is turned to admit high-pressure oil to the cylinder until the piston has completed its upward stroke. The cock is then turned to shut off the high-pressure oil and to connect the cylinder to a drain line. With the pressure released, the piston drops to its lower position by reason of its own weight. This cycle is repeated until the spindle is rotated the desired amount.

In order to reduce the friction when starting the rotors from rest by means by this jacking gear, provision is made to raise the journals by admitting oil to the bottom of the bearings at approximately 1200 lb. per sq. in. in pressure. This oil is admitted to each bearing at two points. Figure 4 shows in detail the connections made for this purpose.

This jacking gear is furnished primarily to rotate the turbine spindle a part of a revolution at certain intervals just following a shutdown in order to eliminate the spindle deflection which occurs if the spindle is allowed to remain in one position throughout the cooling period. If the spindle is rotated at intervals (the exact duration of which is best determined by actual experience with each machine) excessive deflec-

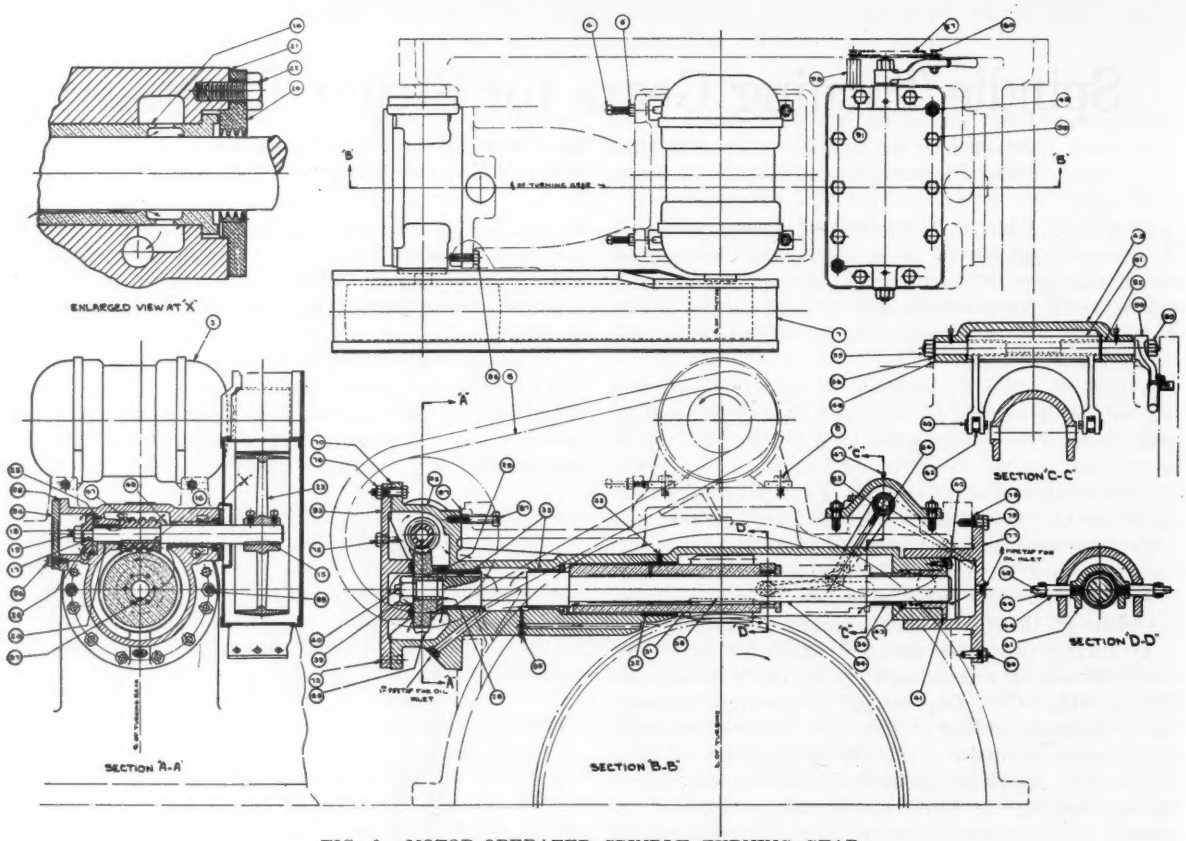


FIG. 2. MOTOR-OPERATED SPINDLE TURNING GEAR

tion will be eliminated and the time required for the subsequent starting will be greatly reduced. If a motor operated turning gear is installed which is capable of rotating the spindle at slow speed but which does not have sufficient torque to start it from rest, this jacking gear can be used to start the rotation and the turning gear then engaged.

The purpose of this turning gear is to keep the turbine spindle rolling slowly after the inlet steam has been shut off until the spindle has cooled to approximately room temperature. This procedure eliminated the possibility of the spindle becoming distorted due to temperature differences within the cylinder, thus making it possible to bring the unit up to speed in a much shorter time when it is again needed. It is important to note that the design does not contemplate any attempt to start the spindle from rest by means of this turning gear. Therefore, it must be engaged before the spindle has stopped rolling. If the spindle is at rest and it is desired to put the turning gear in operation, the spindle must be started by some other means before the turning gear is engaged.

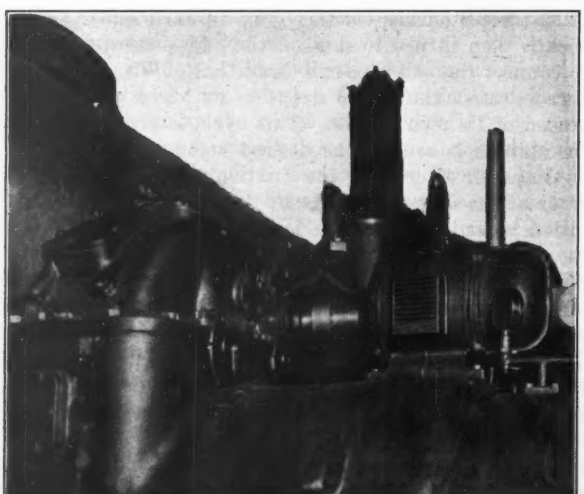


FIG. 3. A SPINDLE TURNING MOTOR IN HELL GATE STATION

Figure 2 shows a sectional assembly of the mechanism, which is mounted on the turbine coupling cover. Its principal parts are a driving motor, two sets of worm gearing and a hand-operated clutch mechanism for engaging the gear. The motor is connected to the first worm by means of a belt which allows slippage when the gear is engaged while the speed of the spindle is lower than the corresponding speed of the gear. The motor speed is reduced by the belt drive and the worm gearing so that the turbine spindle revolves at approximately 25 r.p.m.

Referring to Fig. 2, the motor 3 drives the worm 67 through belt 6, pulley 23 and shaft 68. This worm 67 meshes with the worm wheel 69 which in turn drives the shaft 34 and worm 31. This worm meshes with the worm wheel F which is shrunk on the turbine spindle coupling sleeve. The worm 31 is free to slide on the shaft 34 and key 38. With the worm in the position as

shown, the turning gear is engaged, while with the worm moved to the right (as shown in dot and dash) the gear is disengaged. By means of the clutch (as shown in detail DD), connecting links and lever 50, the worm can be moved and the gear thus engaged or disengaged by hand.

Due to the direction of rotation of the turbine spindle, as long as the turning gear is driving the spindle the thrust on the worm 31 will be toward the left and the worm will remain in the engaged position; however, if the speed of the spindle increases sufficiently to drive the turning gear, the thrust on the worm 31 will be toward the right and, due to the angle of the teeth, the worm will be moved to the right and disengaged. Therefore the turning gear automatically disengages whenever the turbine speed becomes higher than the corresponding speed of the gear. Also, in order to be able to engage the gear by means of the hand lever, the speed of the gear must be slightly higher than the corresponding speed of the spindle.

When the turbine spindle increases in speed and the gear automatically disengages, the worm may be thrown to the right with considerable force. Therefore an oil dashpot is provided between the bushings 36 and 41 to act as a shock absorber. The space between these bushings is kept full of oil at all times, being supplied from the main lubricating system, and the bushing 36 is free to slide on the shaft 34; consequently, when the worm strikes the bushing 36, the force of the impact is absorbed in the dashpot.

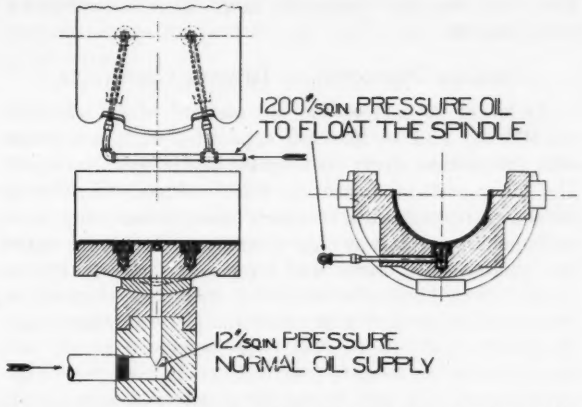


FIG. 4. HIGH-PRESSURE OIL SYSTEM USED TO FLOAT THE SPINDLE ON AN OIL FILM BEFORE TURNING

Rebuilding Boiler Plants for Higher Efficiency

INCREASED COMBUSTION SPACE, HIGHER SETTINGS, STOKERS, PULVERIZED COAL AND AIR HEATERS ALL USEFUL IN RECONDITIONING EXISTING PLANTS TO BURN MIDWESTERN COAL ECONOMICALLY. BY JOHN HUNTER*

MUCH HAS BEEN DONE in the last twenty years toward the development of equipment for efficiently burning Illinois and Indiana coal, particularly in stationary boiler plants. This period of time has seen the major change from hand firing to stoker firing and, more recently, firing of coal in pulverized form, higher boiler settings with large furnace volume, and the refinement of detail in furnace and stoker design. The addition of the economizer or air preheater in later years has served to raise the standard of efficiency in the generation of steam from coal by the reduction in the final flue gas temperature leaving the heat absorbing medium.

Indiana and Illinois bituminous coals contain from 35 to 40 per cent volatile, 5 to 20 per cent ash, 5 to 12 per cent moisture and proportionate amounts of fixed carbon. For efficient and smokeless combustion, it is necessary to make proper provision in the design of the fuel burning equipment to burn this high volatile completely and properly dispose of the large quantity of ash, which is likely to be relatively low in fusion temperature.

The action of bituminous coal, hand fired on an incandescent fuel bed is as follows: The fresh coal closes the openings in the fuel bed and tends to prevent the filtration of hot air through it to burn the volatile being distilled at a very rapid rate. The combustible gas formed by the decomposition of the moisture of the coal, and the heavy hydro carbons being distilled and broken down by the high temperature into free carbon and lighter hydro carbons, are not at a high enough temperature to burn. The consequence is that large quantities of smoke exist above the fuel bed and unless means are provided for completing the combustion, this material will be carried through the boiler and chimney into the open air. The action of the boiler shell and tubes is that of a condenser, tending to keep, or further reduce, these unburned combustibles below their kindling temperatures.

If, at the time of charging the green coal, i.e., during the period of volatile distillation, oxygen can be brought into contact with the volatile and free carbon, at sufficiently high temperature to cause kindling, and if sufficient time is allowed for the completion of the process of combustion before the gases are brought again below their kindling temperature by the chilling action of the boiler tubes, smokeless and efficient combustion will have been achieved.

Originally, the idea was to get the heat transmitting surfaces as close to the fuel bed as possible and to have the flames strike these surfaces. The old hand-fired, horizontal return tubular boiler, with its extremely low setting, may be taken as an example. Many of these boilers are in operation today. Hand-firing methods, no matter how carefully carried out, will result in large quantities of smoke.

Realizing that the volatile and combustible gases above the fuel bed were not being burned because they were below their kindling temperature, attempts were made to raise the temperature, by means of coking arches and the dutch oven or extension furnace, with its highly heated refractory top directly over the fuel bed.

*Consulting engineer, St. Louis, Mo. From a paper presented before the Third Midwest Bituminous Coal Conference at Purdue University.

The result was that somewhat more efficient combustion was achieved.

Stokers Developed to Improve Conditions

In order to correct the old method of intermittent hand firing and to increase capacities with low grade coal, the natural draft chain grate stoker was developed. The labor costs of operation were reduced but, due to the low settings used in the early installations, they were bad smokers and it was only after the boilers were raised and combustion volume and length of flame travel increased that high efficiency and smokeless combustion were attained with this equipment. Several years later, the forced draft chain grate was developed and it was proved a very successful unit in burning low grade high ash coal with low ash fusion temperature at high capacity and rating, due to the better distribution and supply of air.

Overfeed stokers are simply a modified form of hand firing, except that the coal is continuously fed into the chamber from above, by gravity, coking and carrying the volatiles over the incandescent fuel bed.

Underfeed stokers are operated on a different principle. The green coal and air are forced in beneath the burning fuel bed so that the distilled volatile is carried up through the incandescent zone. It was designed originally for the use of coal of high fusion point ash. With the advent of high settings, large combustion chambers and water-cooled furnaces, it is now being successfully used with coals of high ash content, with low fusion point ash.

Finally it was realized that having the flames strike the heating surface resulted in the condensed action of cooling and keeping the volatile and other combustible gases below their kindling temperature and that enough time and space for proper mixing of the volatile and the oxygen necessary to burn them was not being provided. The result was the boilers were raised and the combustion space has been increased from a ratio of less than 1 cu. ft. per rated horsepower to 6 or 10 cu. ft. per hp. in the later powdered fuel installations.

Low Settings, Poor Draft, Insufficient Furnace Volumes Handicap Old Plants

With the old small combustion chamber, the ratings were very low, ranging from 75 to 125 per cent. Many plants now run as high as 400 and 500 per cent during peaks and emergency requirements, and 300 per cent of rating for continuous operation is quite common practice. Burning of soft coal successfully depends to a considerable extent on having a good draft. In considering the reconditioning of the older installation, the cost of making the necessary changes is usually the principal interference. The available draft is often low, requiring either an increase in chimney height or the use of induced draft fans. The boiler as a rule being low set, it requires either the raising of the boiler or sinking of a pit to give the necessary furnace volume, and length of flame travel. The necessary air for higher capacity and better combustion is usually obtained by the use of forced draft equipment. These generalities apply in all sizes of equipment from the smaller heating plants to the larger utility stations.

In the smaller commercial and industrial plants and in office buildings where they generate their own electric requirements, the h.r.t. boiler has been extensively used. These boilers are usually low set, hand fired, most inefficient and bad smokers. In most cases, the boilers are crowded into basements with no possibility of raising them to give the required furnace volume. In such cases, the admission or injection of large quantities of air distributed over the fire will eliminate the smoke but will not increase the efficiency. Although there would be a gain in efficiency due to the more complete burning of the volatile, this gain is balanced by the increased loss in sensible heat in the flue gases, due to the much higher excess air maintained.

Overfeed inclined stokers will help some at low rating, but to get the required furnace volume the necessary pit excavation for the stoker is frequently impracticable. In most cases, this applies to the chain grate stoker which requires high settings and for which space must be provided for the receiving and removal of ashes.

In such cases, where head room is not available, the ram type of underfeed stoker lends itself to the requirements. In most cases, a small pit for the stoker installation will give the necessary furnace volume and the improved efficiencies obtained will reduce the coal bill from 15 to 40 per cent and materially improve the capacity without smoke. The great difference indicated in possible saving is due to the wide variation in conditions existing before the changes are made. Where ratings are very low and operation carefully carried out, the lower limit of saving would apply. Where the equipment is being crowded and operation poor, the larger saving may easily be obtained.

Old Water-Tube Boilers

In the older installations of water-tube boilers, either horizontal or bent-tube type, we find the boilers set low with a small combustion chamber and hand fired. The efficiency of this equipment burning Illinois or Indiana coal is very low compared with modern equipment, it smokes badly, and with the high ash content and low fusion point, fires have to be cleaned frequently to get the desired capacity.

In many cases, natural draft chain grate stokers are installed with small combustion chambers. These units reduce the labor of shoveling coal into the fire and removing the ash from the grate but they too smoke badly and are inefficient. As in the h.r.t. boiler, steam air jets can be installed over the fire, relieving the smoking condition but the inconvenience and noise of this equipment cause the firemen to be indifferent to its use and no increased capacity or efficiency can be expected.

Side dump underfeed single or twin retort stokers, requiring a minimum of space for installation, are more effective in meeting the requirements for higher capacities and greater economy with less smoke. The forced draft chain grate stoker has also been very effective in some of the older installations, especially where space and head room is available for its installation. In such cases, from 70 to 75 per cent efficiency has been obtained with high capacity.

As noted above, to improve these existing old plants materially for higher economy and smokeless operation, larger combustion chambers are necessary with the installation of either the forced draft chain grate stoker or the forced draft underfeed stoker. To bring this

about, the boilers must either be raised or the floor lowered. In most cases, the increased capacity and efficiency obtained from these changes will compensate for the expenditure involved.

In installations of this character, many improvements have been made by the use of modern stokers, or where it is possible to remove the stoker entirely, the use of pulverized fuel has been successful, especially where the boilers are over 500 hp.

The Ashley Street Station of the Union Electric Co. of St. Louis is an example of the effectiveness of the change to powdered coal. The boilers, 550 hp. each, set six feet from the floor, were originally served with natural draft chain grate stokers. The maximum rating burning Illinois Screenings was 135 per cent with an efficiency of 60 per cent. With the demand for higher capacity and efficiency, the floors were lowered five feet, increasing the furnace volume, and the underfeed ram type stokers were installed, which raised the capacity to 220 per cent, and the efficiency to 70 per cent. With a still further demand for higher capacity and efficiency the stokers were removed, the space occupied by the stokers and ash hoppers was utilized for a large combustion chamber with water walls to reduce furnace maintenance, and unit type pulverizers were installed. This installation raised the capacity to 330 per cent boiler rating, with an efficiency of 82 per cent. It is reported that the increased economies and higher capacities obtained in this plant have warranted the expenditure for the changes. Some of these boilers have been in continuous service for over twenty years, and are still doing good work.

In some of the older installations where space is available, the use of an air preheater has resulted in a marked saving in fuel by the reduction of the flue gas temperature and reduction in loss in unburned combustible due to the higher air temperature.

In some of the older plants where steam is generated at about 150 lb. pressure and used for engine-driven machinery, for driving electric generators and process work, and where the boilers are old and the fuel burning equipment is inefficient, new boilers with modern fuel burning equipment have been installed within the old boiler room. In such cases, the steam pressure can be raised to 400 lb. or higher. With this higher pressure, steam can be passed through a steam turbine, generating electric power, the turbine so designed that it will exhaust at 150 lb. for use in the old equipment, or exhausted at a lower pressure and bled at the pressure desired for driving the machinery. Frequently the high-pressure steam is passed through a reducing valve to the pressure required by the older equipment.

With the installation of new boilers of this class, either modern stokers or pulverized coal equipment can be installed with superheaters, water walls and preheated air, which will increase the capacity and improve the efficiency to warrant the expenditures made and result in smokeless operation.

Air Lift Pumping Installations

DATA AND OPERATING RESULTS ON SEVERAL TYPICAL PLANTS UNDER VARIOUS CONDITIONS

IN A PREVIOUS article,* general principles and construction of the air lift were discussed. This article will treat briefly a few actual installations of air lifts to show conditions under which they operate and some of the equipment used for this work.

Figure 1 shows one of the wells under construction in a group of seven installed for the city of Amarillo water supply. These are air-made wells, as previously described, put down in beds of fine quick-sand at a depth of from 30 to 150 ft. below the surface. By repeated back-blowing and raising of the outer well casing, gravel was introduced around each well, replacing the sand, until each well gave a flow of at least 500 g.p.m.

Six of these wells are operated by air lifts, compressed air for which is furnished by the compressors shown in Fig. 2. These are Sullivan 900-c.f.m. units, belt-driven by G. E. 150-hp., 720-r.p.m., 2200-v., 60-cycle, synchronous motors.

Data on two air lift wells, installed to supply water for a large railroad yard and shop, should prove of interest. These were 12 in. in diameter, 863 and 869 ft. deep, with slotted strainers set in the various sand and gravel strata. The total water bearing strata amounted to 280 ft. Back blowing removed most of the sand and allowed gravel to settle around the casing. Air for this installation was supplied by two angle-compound compressors, 20 and 12 by 14 in. in size, driven by belt from two oil engines.

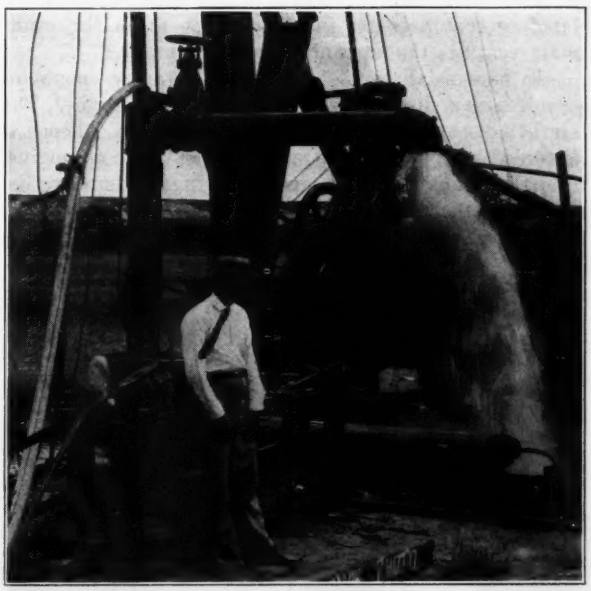


FIG. 1. ONE OF THE WELLS UNDER DEVELOPMENT AT AMARILLO

*Pumping Water with Air Lifts, page 511, May 1, 1930 issue. Power Plant Engineering.

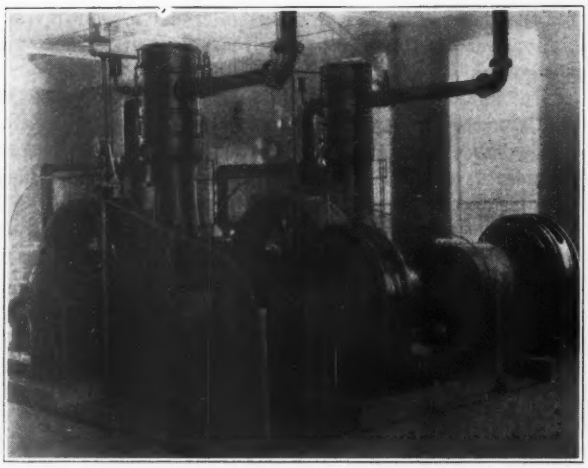


FIG. 2. SYNCHRONOUS MOTORS DRIVE ANGLE-COMPOUND COMPRESSORS AT AMARILLO

Operating conditions of these wells are as follows:

	Well No. 1	Well No. 2
Lift	282 ft.	266 ft.
Gal. per min	731	659
Gal. fuel oil per hr	11.7	11.6
Cost fuel oil per hr. at 5c per gal.	$0.585	$0.58
Gal. pumped per hr	43,860	39,500
Cost fuel oil per 1000 gal	$0.0133	$0.0147

In a number of installations, excellent economy has often been obtained by driving the compressor from an oil engine, either direct connected or by belt, to furnish air to bring the water to the surface. Then a centrifugal pump, belt driven by the same engine can deliver the water to the mains or to a storage tank or reservoir of some kind. Arrangements of this type can be regulated so that pressure in a standpipe or in the water main controls the amount of water pumped.

In one installation of this kind, an angle-compound compressor is direct driven by a vertical oil engine. The air lift discharges to a small receiving basin, whence it is forced by a centrifugal pump, belted to the oil engine, into the mains. Air lift and centrifugal pump are designed so that they handle the same amount of water. Operating conditions at this plant are given as follows:

FIG. 3. DISCHARGE OF WATER FROM AIR LIFT WELL IN MEXICO

FIG. 4. OIL-ENGINE-DRIVEN COMPRESSOR SUPPLIES AIR FOR WELL SHOWN IN FIG. 3

Lift in well	344 ft.
Pumping head, centrif. pump	97 ft.
Total head	441 ft.
Horsepower developed by oil engine	90
Theoretical horsepower, including friction	33.7
Overall efficiency, per cent	37.4
Gal. fuel oil per hr	7
Oil cost at 6c per gal	$0.42
Gal. pumped per hr	14,820
Fuel cost per 1000 gal	$0.02834
Lubricating oil cost per 1000 gal	$0.00025

Another interesting air lift installation is that shown in Fig. 3. This is an air lift well supplying water for the cotton farm of Nuevo Linares in Coahuila, Mexico. The Ingersoll-Rand P.O.C.-2 oil-engine-driven air compressor supplying air to it is shown in Fig. 4.

Lincoln Oil Refinery Installs New Boiler

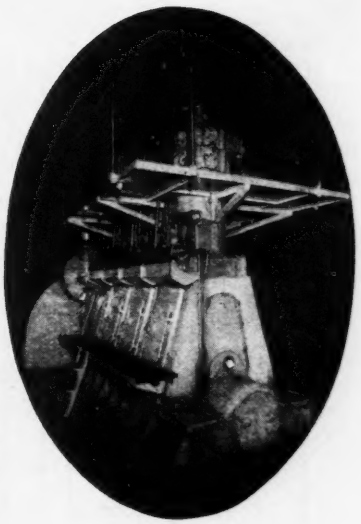
IN THE March 1 issue of Power Plant Engineering under the above title, the name and type of motor driving the coal pulverizer were incorrectly stated. The pulverizer is an air-swept ball mill of 7500 lb. an hour capacity and is driven at 30 r.p.m. by a 75-hp. Triumph Type TR15 self-start, high-torque, across-the-line motor.

TWELVE ELECTRIC POWER cables will be laid simultaneously this spring on the bed of the Delaware River near Baltimore by the Consolidated Gas Electric Light & Power Co. The cables, being manufactured at the Schenectady works of the General Electric Co., will be approximately 2200 ft. long, and each will weigh 35 t. on the reels.

Unusual problems confront the engineers in the actual laying of the cables. The Delaware River at the point selected for the cable is a navigable stream, hence the decision to lay all twelve at once. The cables will be lowered from a barge to the bottom of the river, in a ditch specially dredged.

The cables will carry 35,000 v. to a rapidly growing section of Baltimore on the other side of the river.

DIESEL ENGINE UPKEEP



PART II. CYLINDER TROUBLES PREVENTED BY AVOIDING IMPROPER LUBRICATION AND FUEL CONSUMPTION, INTRODUCTION OF SCALE OR GRIT AND UNEQUAL HEAT DISTRIBUTION. CORRECTION METHODS

IMPORTANCE OF KEEPING records of changes, repairs and replacements has been urged and a method of collecting these data has been presented in the April 15 issue. The equipment record form illustrated on page 487 of the May 1 issue may be applied to the Diesel as well as other plants. Records of wear at various points on detail parts of the Diesel engine which are also of service will be discussed under succeeding headings.

Since most large Diesel engines, excepting those used for pipeline service, are of the vertical type, this discussion will be considered primarily with that type in mind although most of the principles apply to both types. Cylinder trouble results from one or more of the following: incorrect kind of lubricant or method of cylinder lubrication; improper combustion conditions; scale formation due to use of hard water; grit which is taken in with the air or buckling of parts due to unequal heat stresses.

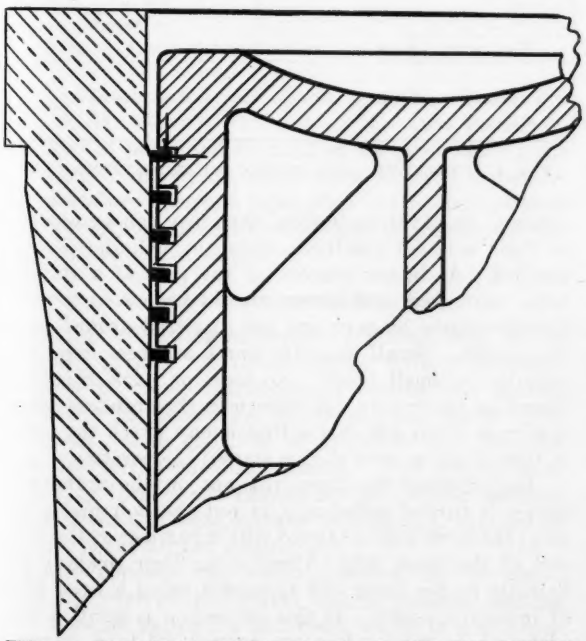


FIG. 1. RELATION OF PISTON RING AND ITS GROOVE SHOWING HOW GAS PRESSURE SEALS THE PASSAGE AGAINST LEAK WHEN THE RING FUNCTIONS PROPERLY AND SHOWING METHOD OF AVOIDING FORMATION OF RIDGES BY OVERRIDING COUNTERBORE

CYLINDER LUBRICATION

Mineral oils alone should be used on Diesel engines; compounded oils containing animal or vegetable oils cause trouble due to tendency to emulsify and foam. Especially is this true for the cylinder where it is essential that lubricant exposed to the high temperature of combustion should be consumed without leaving a residue of any kind. Use of unsuitable lubricating oil for this purpose will result in carbon deposits, sticky piston rings, blowing pistons and contamination with carbon of the crankcase oil. A reliable test for emulsion may be made as follows: Mix 1 oz. of oil with an equal amount of distilled water, heat this mixture to 180 deg. F., then shake for 5 min. If, after standing 1 hr., the oil and water are separated, there will be no danger of emulsifying in use.

With proper working conditions, the piston rings will move freely in their grooves and, due to the gas pressure which has been communicated to the top and inner part of the ring, each ring will bear against the cylinder wall and bottom of groove sealing the ring, as illustrated in Fig. 1. If, however, carbon deposits are formed in the groove, the ring may be prevented from seating properly as shown in Fig. 2 and a loss in compression pressure, hence in power, will result.

TOO MUCH LUBRICANT CLOGS RINGS

If too much lubricant is fed, the oil will not be completely burned due to lack of combustion time for the quantity of oil fed and the rings in the upper grooves will stick. Under the circumstances, since the cylinder wear is greatest at the top, the rings will be pressed farther into the grooves at the bottom of the stroke than at the top and will be held there by the sticky mass surrounding them. When the piston then reaches the top of its stroke, the gases may pass around the upper rings

as shown at B, Fig. 2. This process may continue until the successive rings are stuck, likewise causing the piston to blow.

It is essential, therefore, that the smallest amount of oil, consistent with good lubrication should be fed. This quantity is best found by trial, records being taken of the condition of the cylinder and piston under different rates of feeding. The condition of the bottom of the piston as it projects out of the liner at each revolution is a good telltale. This part of the piston always should be cool enough to be touched with the hand without discomfort. If black gummy oil covers this part, the

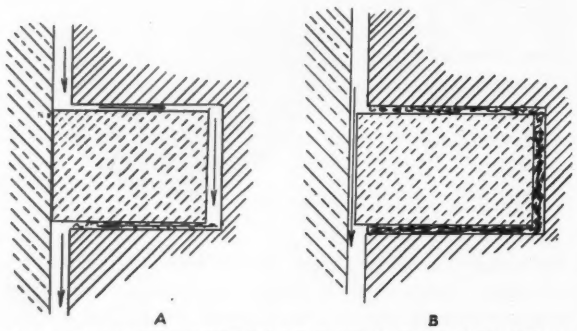


FIG. 2. ENLARGED SECTION OF RING AND GROOVE SHOWING HOW LEAKAGE RESULTS FROM (A) CARBON DEPOSITS UNDER THE RING AND (B) PASTY ACCUMULATIONS AROUND THE RING

lubrication and combustion conditions should be investigated and the operation restored to a clean burning condition.

Gumming up of the piston rings may be caused also by use of improper oil, by insufficient compression, by incorrect spray valve or spray nozzle action or by too low or too high fuel injection pressure. The deposit of gummy residue may not manifest itself just after it has been deposited while the engine is running because the sticky mass is then hot and yielding but after the engine is stopped this mass may harden sufficiently even to grip the piston and cylinder and on attempting to start the engine it will be found to be "frozen."

Causes of Cylinder Scoring

Insufficient lubrication, piston distortion or grit in the air or lubricant may cause scoring of the cylinder. Local scoring may be remedied by rubbing the injured part with an emery stone and by careful use of scraper. Every particle of emery must be wiped out of the cylinder, however, before it is put into service again. Grooves and ridges due to side thrust of the piston under the high cylinder pressure may be formed also but if these grooves do not exceed 0.005 in. in depth they will not seriously affect operation; if they are deeper, the liner should be rebored. Ridges formed by the upper ring at the end of the stroke may be avoided by causing the upper ring to override the counterbore as shown in Fig. 1. The edge of the counterbore should coincide with the center of the upper ring at the extreme upper end of the stroke.

Some Diesel operators hold that the maximum allowable liner wear should be 0.001 in. per 1000 hr. of service. The rate of liner wear differs widely, however, in different parts, being greater at points parallel to the shaft near the top than at points at right angles to the shaft near the top. The wear should be tested every 1800 hr. of actual operation. When the compression becomes so low as to cause ignition failure or high fuel consumption, the liner should be rebored or renewed. Normally, the liner will require replacement or reboring every 3 to 7 yr. according to the amount and conditions of service.

Records of cylinder and piston wear are easily kept on 5 by 3-in. filling cards as shown in Fig. 3. All measurements are made with a micrometer and results recorded in thousandths of an inch. Diameters of cylinder bore and piston, I, are measured parallel to the engine shaft and diameters, W, perpendicular to L. The amount and kind of lubricant is noted in the last column. A card must be kept of each cylinder. The cylinder numbers begin with 1 at your left as you face the engine on the front side.

Cylinder Liner Replacement

Liners usually permit of at least one reboring. When replacement is necessary, the worn liner, which is usually removable in large engines, may be withdrawn easily by the use of a long bolt and blocking as shown in Fig. 5. Wood blocks are easily obtainable and do not mar the surfaces of the cylinder or its liner. Also they are more readily drilled for the bolt. A plate or large washer should be placed under the nut and between the lower block and head of the bolt.

Removal of the cylinder head in preparation to withdrawal of the liner should be done systematically. All nuts, the cylinder head, and all parts that are to be

CYLINDER CLEARANCE MEASUREMENTS

ENGINE NO._____ CYLINDER NO._____ DATE_____

DISTANCE FROM TOP - INCHES	CYLINDER		PISTON		CLEARANCE		LUBRICATION CONDITIONS
	L	W	L	W	L	W	
3							
10							
20							
30							

FIG. 3. CYLINDER AND PISTON WEAR RECORD CARD

removed should be so marked that they can be returned to their original positions when the cylinder is reassembled. As in the removal of any part of a machine, bolts, nuts, pins and screws should be put in their respective places at once and not scattered around or on the engine. Small separate parts are best kept temporarily in small boxes. No tools or parts should be placed in the engine. A wrench in the crankcase of an engine or a nut left in a cylinder may wreck the engine in time if not as soon as it is started in operation.

In removing the liner, the nut on the withdrawal device is turned sufficiently to put the bolt under tension; the liner is then tapped with a hammer at the lower end of the inner side. Usually the liner projects sufficiently at the lower end to permit using a wood block of indefinite length. If this projection is small, a steel plate whose outer edges are turned off to a diameter slightly smaller than the cylinder bore should be used in place of the lower wooden block.

In assembling the new liner, care must be taken to

have the oil holes correspond with those in the cylinder jacket. In lowering the liner in the cylinder, the use of bagging or cloth avoids marring edges.

Before replacing the piston, the cylinder should be swabbed with sufficient clean, fresh oil to lubricate the rings when the engine is turned over. Oiling the piston before it is replaced is ineffectual because it is almost impossible to keep the oily surface clean while it is being handled and handling is less convenient. Care must be exercised, when replacing the piston, to see that it goes back in its former position and that the oil groove is on the proper side so that oil may be supplied to the piston pin.

After replacing the cylinder head, the nuts on the studs should be drawn up in opposite pairs. After two nuts on opposite side of the cylinder have been drawn up lightly, another similar pair approximately at right

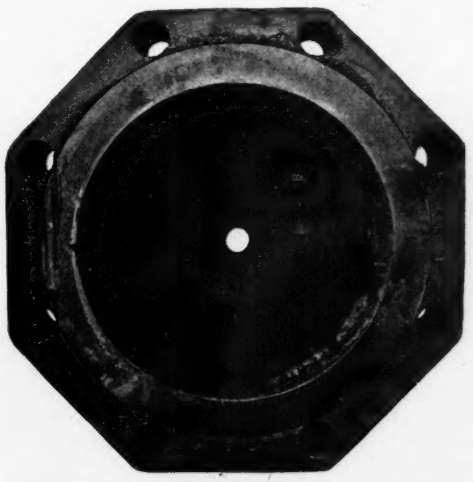


FIG. 4. EXTENT TO WHICH CARBON ACCUMULATIONS MAY DEVELOP IN COMBUSTION CHAMBER IF TOO HEAVY FUEL OIL IS USED OR BREAK-DOWN OCCURS IN THE LUBRICATING OIL. COURTESY OF THE TEXAS CO.

angles to the original pair should be tightened slightly. In a similar manner, the rest of the nuts should be tightened in pairs and then all of the nuts made tight by successive one-eighth turns made on pairs as before. This procedure insures a tight joint if the surfaces have been properly made and avoids unequal crushing of the gasket where one is employed.

Cylinder Fracture Prevention

Methods of casting at present available, such as use of chills; advance in Diesel engine design, in which simplicity of form, uniformity of cooling and careful distribution of stresses are employed; and use of superior metal, make cracking of cylinders and cylinder heads due to imperfection, remote. With proper care, which may involve the installation of a water softener and of devices to warn against overheating, rupture of these parts should not occur.

Water deposits may cause cracking in two ways: filling up part of the jacket causes unequal heating hence unequal expansion and scale, which is a non-conductor, may build up until the part receives little or no cooling effect from the water and then chip off suddenly exposing a very hot part to cool water, resulting in a fracture. Scale formation may be avoided by methods to be described in a later issue. Excessive temperature of exhaust is quickly indicated by a pyrometer.

Unwatched cooling water temperatures lead to trouble. Excessive loading increases the rate of heat transference required of the jacket. If the temperature of the cylinder is permitted to rise too high the lubricating oil thins out and wear becomes excessive. Moreover, the higher temperature increases the rate of salt deposit in the jacket which, in turn, reduces the heat conductivity of the walls at the place—upper end—where there is most need of rapid dissipation of heat.

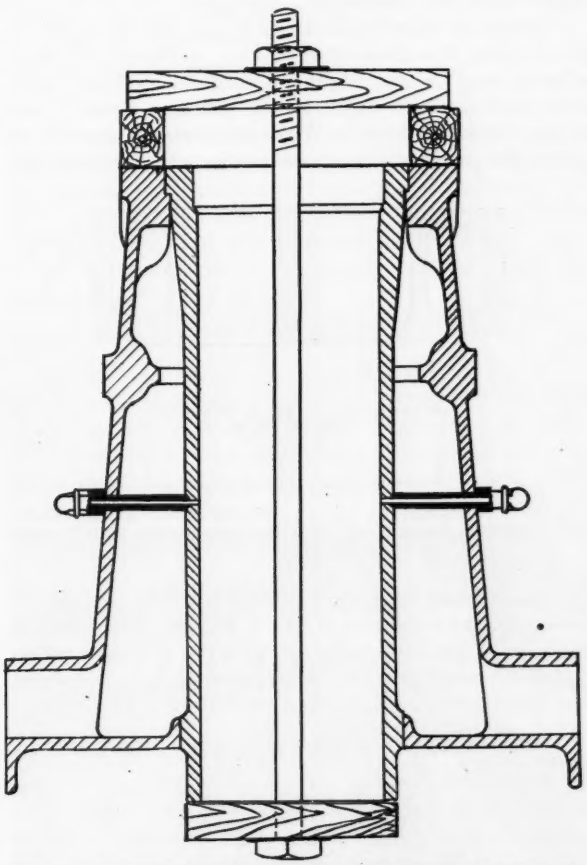


FIG. 5. METHOD OF REMOVING CYLINDER LINER BY MEANS OF LONG BOLT

Formation of air pockets in the jacket also causes unequal heating. Such pockets can be avoided by drawing off the cooling water of each section of the water jacket system from the highest, which is also the hottest point in the section. Because of the closer proximity of the upper ring to the combustion chamber the pressure on this ring, hence that exerted by this ring against the cylinder wall, is greater than pressures on other rings. Wear at the top of the cylinder is therefore greater than at other parts, notwithstanding piston side thrust which exists at the lower end of the cylinder.

Some kind of water temperature indicating device that is plainly visible from the operating floor, is therefore essential. A protected thermometer is generally more serviceable for this purpose than an open discharge funnel because the active churning of the water at this point produces aeration which increases corrosive action in acidified water.

Sliding Joints Avoid Heat Stress Formation

In cylinders having the liner cast integral with the outer jacket there is a tendency for the liner to elongate more than the outer jacket wall under operating conditions because the temperature of the liner is the greater. Some cylinders have a removable jacket on the upper and hotter portion of the cylinder. Most large engines are now built with separate liners. Besides the advantage of freedom to expand and contract independently of the cylinder jacket, the use of a separate liner permits of its removal without dismantling much of the engine when it is desired to replace it.

Cracks in cylinder liners or heads may be detected by a white steaming exhaust; the particular cylinder affected may be located by opening the cylinder indicator cocks in turn until the one giving a steam vapor in the exhaust is found. When small cracks, located in places that are not dangerous, are formed, they may be

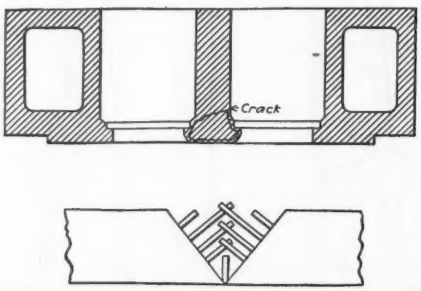


FIG. 6. PREPARATION OF CYLINDER HEAD FOR WELDING. ABOVE, LOCATION OF CRACK; BELOW, V-CUT AND ARRARNGEMENT OF STUDS

prevented from spreading by drilling a hole just beyond the end of the crack and plugging it again. The rounded surface of the hole stops the growing cleavage which otherwise would continue to increase due to vibrations and other movements of the engine.

Proper Welding Results in Sound Repairs

Autogenous welding, when properly applied, produces a successful repair of even that most complicated part of a Diesel engine, the head. Successful welding requires careful preparation of the part by cutting a V groove, whose sides are about 80 deg. apart, to the bottom of the crack and then interlacing the sides with screwed studs as shown in Fig. 6. The upper studs are then removed to give access to the bottom of the V and the welding-in of the new metal started at the bottom. As the V is filled up, the upper studs are screwed in so that all of the studs are embedded in the filler metal when the weld is completed. Where the section is deep, the sides may be given a curvature whose radius and whose width of opening at the top is the thickness of the metal being repaired. Curving the surfaces affords a wider opening at the bottom where it is needed while greatly reducing the amount of filler metal and work required. If the crack is near the outer edge of the head, where expansion and contraction stresses can be accommodated, oxyacetylene welding may be used but if the crack is near the center of the head or surrounded by unsymmetrical masses of metal as is usually the case, electric welding must be resorted to. Where the weld crosses a valve-housing seat, great difficulty is experienced ordinarily in machining the seat accurately due to springing of the cutting tool when it strikes the junction between new and old metal. This difficulty has been met by the use of tungsten carbide tools which cut hard metal with ease.

Middle West Division, N.E.L.A. Meets at Des Moines

K. R. MACKINNON, Omaha, Nebr., was elected president of the Middle West Division of the National Electric Light Association at its annual three-day meeting in Des Moines, Iowa, April 23-25, attended by 700 representatives of utilities from states in that district.

Mr. MacKinnon succeeded Alex D. Bettis, Kansas City, as head of the division. Because of illness, Mr. Bettis was unable to attend the meeting and in his absence, Mr. MacKinnon delivered the president's address. Other officers for the year are: C. A. Leland, Jr., Des Moines, first vice-president; W. W. Austin, Cottonwood Falls, Kan., second vice-president; J. E. Harsh, Joplin, Mo., third vice-president. Mr. Leland was general chairman in charge of the convention.

Brilliant picture of the future of the industry was drawn by A. D. Bailey, chief engineer of the Commonwealth Edison Co., Chicago. Discussing the growth of the electrical industry, Mr. Bailey said, ". . . assuming a 10 per cent annual increase, our output in 1954 will be about 1,000,000,000,000 kw-hr. . . . the increase in 1955 will be 100,000,000,000 kw-hr., an amount greater than the entire output of the industry in 1929."

James L. Madden, vice-president of the Metropolitan Life Insurance Co., which at request of the National Electric Light Association, undertook an extensive industrial survey to determine why industries migrate, declared that "we found that real industrial development in middle western cities comes from the springing up of home industries. In this area, 72.8 per cent of gains were from the starting of new industries; 17.8 per cent from branch plants of national corporation and only 9.6 per cent gain from migration of industries."

Introduction of electricity more generally into the farm field will make for higher standards of living, happier homes and reduced costs of production, according to Kirk Fox, editor of Successful Farming, one of the convention speakers.

Sectional meetings to concentrate upon various phases of the industry were held during the session. M. S. Sloan, New York City, president of the association, headed group of speakers at the commercial section. Other papers were presented by C. A. Nash, Davenport, Iowa, general manager, United Light & Power Co.; H. L. Hutchinson, Kansas City, Mo., industrial lighting engineer, Kansas City Power & Light Co.; Walter McCue, National Lamp Works, Chicago, Ill.; Stanley Tabor, Lincoln, Nebr., sales manager, Iowa-Nebraska Light & Power Co.; Earl Nichols, Cedar Rapids, Iowa; George H. Ahlhorn, Topeka, Kan., and Marshall E. Sampsell, Chicago, president of the Central Illinois Public Service Co.; A. A. Rall, Kansas City, Mo.; J. O'R. Coleman, assistant engineer of the national organization, and Frank D. Paine, electrical engineer, Iowa State College, were speakers at the technical division group at which F. C. Arthur, presided.

Moving Terminal Power Plant *of the* New York Central

An Unique Engineering Feat

A power plant a city block in area moved a distance of seven blocks horizontally and lowered into a hole in rock 90 ft. deep. Eighteen months work done in nine months. No interruption to service, nobody injured, no property damaged*

TRANSPOSING the Grand Central Terminal boiler power plant and electric station, which supplied heat, light and power to the whole Terminal development, from its former location on the surface in the

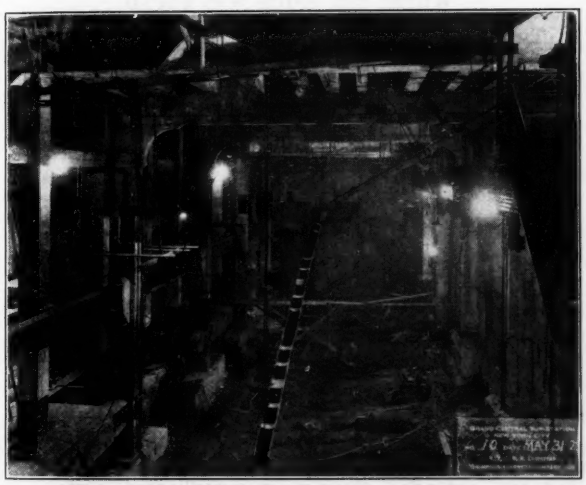


FIG. 1. THE OLD BOILER ROOM, MAY 31, 1929

block bounded by Forty-ninth and Fiftieth Streets and Park and Lexington Avenues, to a deep, deep cellar at Forty-third Street and Lexington Avenue, New York City, was "one of the most intricate and difficult pieces of work that has ever been undertaken in New York City."

The work was recently completed. To other difficulties was added the necessity of doing the work in a limited time so that operations on the new Waldorf-Astoria Hotel, which will occupy the block from which the plant was removed, could be started not later than the first months of this year.

All the engineers had to do was to dismantle a power plant a city block in area and move much of it a distance of seven blocks, add new apparatus, all without interfering with the operation of the terminal or of the trains entering it, without hampering street traffic and finish the job on a scheduled date which seemed appallingly near when work was begun. That is all they had to do; and they did it, not only without delaying train movements, interfering with water supply or heat in the terminal or even annoying a taxi driver, but without damaging apparatus or injuring a workman. It was reported that one of the foremen got a drop of acid on his trousers; but this could not be verified.

As a fair sample of the details involved, take the case of the stand-by batteries.

340 Tons of Cells

At Fiftieth Street the stand-by batteries consisted of 150 cells, each weighing 4550 lb. Each cell consisted of a large wooden lead-lined tank, 7 ft. long, 2 ft. wide, 2 ft. 9 in. deep, filled with plates surrounded by acid. There were two major problems in connection with moving it: first, to move it without injury; and second, to insure an equal reliability of service without it in operation.

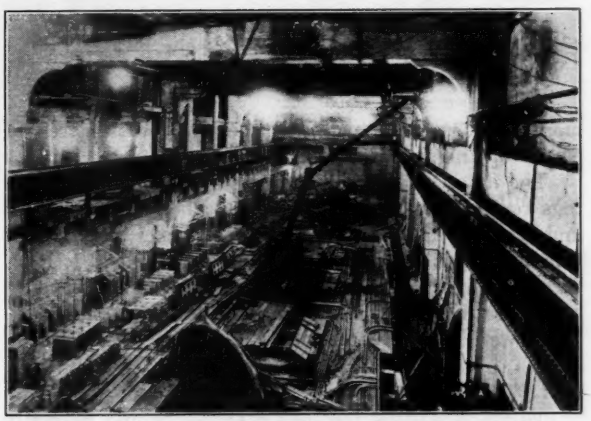


FIG. 2. THE SAME ROOM, ON AUG. 9, 1929

It is usual when moving such a battery to remove the acid and the plates and reassemble them at the new site. In place of this a different plan was decided upon. Part of the acid was removed, the plates were clamped in place, wheels were placed under the tanks and they were hauled from 50th St. to 43rd St. underground by an electric truck, making use of the east suburban trucking platform. In addition to being hauled, each cell had to be lowered by tackle a distance of 55 ft. at 50th St. and raised by an elevator at 43rd St.

Reliability of service was insured during the transfer by connecting the lighting substation at 50th St. to

*Abstracted by special permission from the New York Central Magazine.

the New York Central high tension system and the lighting substation under the Graybar Building to the New York Edison system.

One of the most interesting things about the whole undertaking was that the need for the change had been foreseen and provided four years ago. The late Ira A. Place, senior vice-president, Law, first proposed clearing the 50th St. block for the erection of a building covering its entire area.

Through wise forethought, and at an expenditure of $175,000, a great basement had been excavated under the Graybar Building for the accommodation of the mechanical facilities that could not remain at 50th St. under any plan.

This was the situation when on March 4, 1929, a decision was reached to clear the 50th St. block. In nine

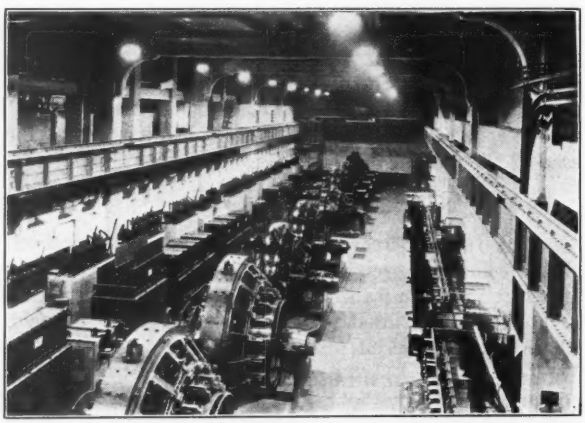


FIG. 3. ANOTHER VIEW OF THE ROOM SHOWN IN FIGS. 1 AND 2. THE COMPLETED SUB-STATION, FEB. 5, 1930

months, plans were made and the block was cleared of electrical and mechanical apparatus.

The dates set for the clearing of the various buildings for demolition were as follows: boiler plant house and stand-by battery building November 1, 1929; traction substation and lighting substation January 1, 1930. In addition, it was necessary to have the steam and hot-water heating plants ready for service on September 20. These were severe requirements but every date was met.

Working Period Cut in Half

To prepare plans for such a project would normally take 6 mo., while a year would be required to execute them. To accomplish this great work in 9 mo. required that it be placed on an emergency basis. No ordinary organization would do. It was decided, therefore, to effect a practical merging of the railroad's engineering forces with those of the contractors.

Although the engineers had determined to the most minute detail what work had to be done and the means for its accomplishment, no drawings, other than preliminary sketches, had been prepared. Information was therefore transmitted verbally to all those coöperating. Red tape was avoided. Every short-cut was adopted. No change in any major plan was made after announcement. All temporary work was eliminated. Work was started in the field under verbal direction, followed by drawings as early as possible.

When the field work was well under way, the work was coördinated by weekly conferences between the representatives of the engineering and the operating departments and the General Electric and Thompson-Starrett companies. A splendid spirit of coöperation prevailed. Under these conditions, the whole project moved forward without hesitation to the sure accomplishment of the general plan.

The problem presented to the electrical department of removing the terminal facilities from the 50th St. block and providing elsewhere, by various means, equivalent facilities, and to make this transfer without interruption of service and in the minimum of time was truly a great problem. It was necessary to make several broad decisions as follows:

The steam generating plant at 50th St. was a neighborhood nuisance, due to the flow of cinders and gases from its stack. The boilers were old and would shortly have to be replaced. No space was available for the reëstablishment of the plant. It was decided therefore to abolish it and take steam from outside sources.

Where the Space Was Found

Two boilers were installed in the 43rd St. underground plant and they were used only in the heating season. It was decided to remove them and use this structure for the accommodation of the apparatus of the lighting and traction substations and the stand-by battery.

The hot-water heating plant, the air compressors, fire pumps, hot and cold-water pumps and other auxiliary apparatus could be accommodated under the Graybar Building in the space previously reserved for them.

The piping system of the terminal being laid out in a square with one corner near 50th St., where steam, water and air were introduced, and another near 43rd St., it was decided to open these pipes at 43rd St. as a new feeding point and to close them at 50th St., thus using the same pipes.

The traction system of third rail feeders, 36 in number, extended through a complicated system of ducts from the substation at 50th St. to various third rail sections on both levels of the terminal. To lead them all to the 43rd St. substation would require an expensive duct system and miles of cable.

It was decided, therefore, to construct a circuit breaker house at 49th St. and connect all these cables to switchboard panels therein, but under distant control from 43rd St.

Twelve cables were connected between the substation at 43rd St. and the circuit breaker house at 49th St. In operation, these cables carry the average current to the circuit breaker house, where it is subdivided among the various third rail feeders. The electrical effect is the same as though the substation had not been moved.

The 43rd St. Boiler Plant was unique in its location. An excavation about 90 ft. deep and 225 ft. long by 60 ft. wide had been made in the solid rock between the Commodore Hotel and the Graybar Building and in this space a boiler plant building had been constructed, containing two boilers, with room for four more. The roof of this plant was a private street, an extension of 43rd St. The plant consisted of four floors; a basement for the handling of ashes, a boiler room, a meter room and the coal bunkers. The stack extended to the top of

the Commodore Hotel and was concealed in that structure.

To convert this building into a substation, it was necessary to remove the boilers, enlarge the basement, construct concrete foundations for the rotaries, provide an operating floor filled with conduits and with spaces for transformers, switchboards, oil switches and other apparatus. Also, crane girders and a 30-ton electric crane were provided.

The meter room was made into an exhaust fan room, taking the air from the top of the substation and exhausting it into the boiler breeching and thence up the stack. The bunker space was converted into a stand-by battery room, said to be the finest in the country.

Thus, the boiler plant consisting of only two boilers, and those operated only in winter, was replaced by the largest substation in the world. Every cubic foot from the basement to the street level was utilized for electrical purposes, and this apparatus was in service at all times in the great work of operating all the trains in the terminal area and lighting the great group of buildings crowning it.

About one-third of the heating in the terminal is done with hot water. Due to the height of the buildings, three distinct systems with different pressures are operated. The heating is done in five large heaters, each weighing 20 tons and constructed like surface condensers.

The problem of their transfer was the most critical in the whole operation for the reason that they could not be released from service until May 21 and positively had to be ready for service on September 20. No other means existed to supply hot-water heat unless they were successfully reinstalled and connected to the necessary steam pipes, pumps and hot-water mains. Every man available was used on this operation and it was the principal objective until accomplished.

On September 19, the heaters were ready for service and a cold wave arrived on the 20th.

Amount of Electrical Material Used

So far as practical, all materials were moved by lowering them on to flat cars at 50th St. and unloading them on the platforms at 43rd St., where they were lowered to their proper level. The unloading of these cars had to be done from tracks which could be kept out of service but a few hours at a time. To remove 30-t. armatures in a limited number of minutes required exceptional skill.

In the buses of the new substation, more than 70 tons of bar copper was used. This all had to be drilled, bent, insulated and supported.

The conduits concealed in the floor of the substation have a total length of 25,000 ft. In each conduit from one to 16 wires are installed.

It was necessary to install and support in an elevated position throughout the terminal, approximately 20 mi. of 3½-in. steel conduits.

Into these conduits and the existing masonry conduits, 35 mi. of cables of the largest size were drawn. These were the lighting and traction feeders. In addition, several miles of high tension and control cables were installed.

From the 43rd St. substation, no less than 134 main cables radiate to various parts of the terminal.

New Switchboards Installed

It was necessary to design and install an entirely new set of switchboards for the lighting and traction substations and an extension of the switchboard of lighting substation 1-B; to provide a large system of air filters to cleanse the air entering the substations, battery room and air compressors. Part of the ventilation system involved the provision of an air intake 10 ft. by 10 ft. square cut through solid rock, so that half the air entering the substation should come from the suburban loop track area, where additional terminal ventilation was necessary. It was also necessary to provide great tanks of 20,000 and 50,000 gal. capacity to contain water for house and fire reserves; to provide means for conserving all the condensate of the hot-water heating and piping systems and use it as part of the plumbing hot-water supply; to provide four additional steam pipe connections with the New York Steam Corporation, three of 16 in. and one of 20 in. in size; to provide new valves for all new piping and to provide numerous other associated items.

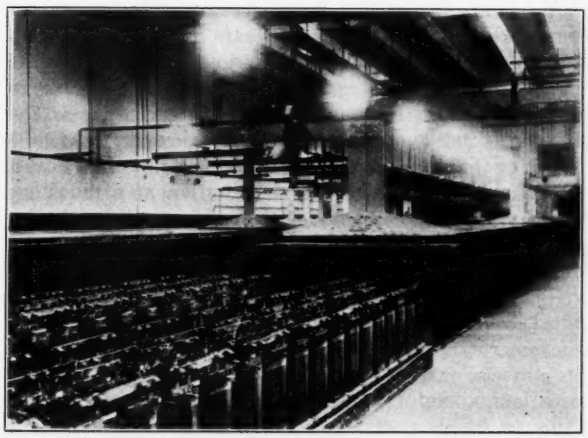


FIG. 4. THE BATTERY ROOM IN THE NEW UNDERGROUND ELECTRIC POWER PLANT

A total of 10 rotaries and their transformers were installed in the new substation. The total weight of this apparatus and other major electrical machinery installed was 850 tons. All of this had to be lowered piece by piece a vertical distance of 50 ft. from the unloading platform to the substation main floor. Three 4000-kw. armatures, each weighing 30 t., were thus lowered. A 4000-kw. rotary assembled weighs 68 t.

The high-tension masonry bus is 175 ft. long and is divided into five sections and connecting to it are 36 high-tension oil switches.

To cover the whole project, it was necessary to prepare 330 drawings covering electrical work and about half that number to cover mechanical features.

It was necessary to install three of the 1500-kw. lighting rotaries at the utmost speed, working night and day. From the time they were taken out of service at 50th St. until they were placed in operation at 43rd St., was from 23 to 26 days.

To install the 4000-kw. units required 90 days after their arrival.

Job Completed on Schedule

All work was completed on time and in accordance with schedule; there was no interruption in the lighting or signal power supply or in the traction current for the movement of trains.

No damage was done to any piece of apparatus during transfer. The facilities removed have been placed so deeply underground that they will never be a nuisance or interfere with the full development of the terminal. They operate in their new surroundings as efficiently and as reliably as in their former locations.

The result of the operation is to remove from the 50th St. block a collection of buildings out of harmony with the splendor of Grand Central Terminal and to permit the erection on their site of a monumental building of surpassing beauty.

Design Features of Distribution Transformers

Adaptation of Standard Parts to Special Applications. Types in Use for Various Purposes. By L. E. Payne*

WHILE NOT USUALLY thought of in this manner a transformer is a bridge between the economical transportation of power and its safe use. It is a known fact that electric power can be transported much more cheaply at high voltages, because of the decrease in power loss with decrease in current and because the apparatus used in transmission is cheaper. At distributing points called substations, the power is transformed and is sent out for distribution at a much reduced voltage. In thickly settled districts, this "feeder voltage," so called, is usually 2300 v. In less settled districts, it may be 4600 v. or 6900 v. and occasionally voltages as high as 13,200 or 23,000 are used in distinctly rural communities. Connecting this "feeder" with the consumer's apparatus is the distribution transformer. Its purpose is to supply power at a safe voltage for use with lamps, motors, heaters and all the varied applications to which electric power is now being put. For lamp loads, voltages of 115 and 230 are common, while for motors, voltages of 460 and 575 are customary.

Because of the rapidity with which new uses of electrical power are continually being found, the problems of the transformer designer are anything but standard. By way of example, the rise of the airplane industry has created a demand for floodlights for landing fields. It has been found that best results are obtained when these floodlights are operated on 32 v., thus necessitating a wide departure from existing designs to take care of this condition.

*Distribution Engineer, Westinghouse Electric & Mfg. Co.

Design Influenced by Economic Conditions

If electrical equipment were designed to the least detail to meet the requirements for which it was built, we should undoubtedly have a piece of apparatus that would follow nicely the theoretical conception of it. In the world of production to be met with today, however, where a multiplicity of parts is to be avoided, design is influenced to a great degree by economic considerations. The distribution transformer offers an interesting study in this field. A common type of construction for this apparatus, especially favorable for comparatively low voltage, small capacity applications, is the distributed shell. In its complete form it is composed of four iron circuits of assembled "L" plates as shown in Fig. 1, those forming the outer part of the magnetic circuit being larger in area than those forming the inner part which is within the coils. The assembled core is shown in Fig. 2.

It is possible to build up the outer circuit with exactly the same plates as the inner circuit when it is necessary to reduce the weight of iron, or where it is desirable to change the ratio of iron to copper loss. In this case, the same coils as before may be used, since the size of the opening in the iron has not been changed.

While the four-circuit or distributed shell type offers the greatest economy in the use of both iron and copper,

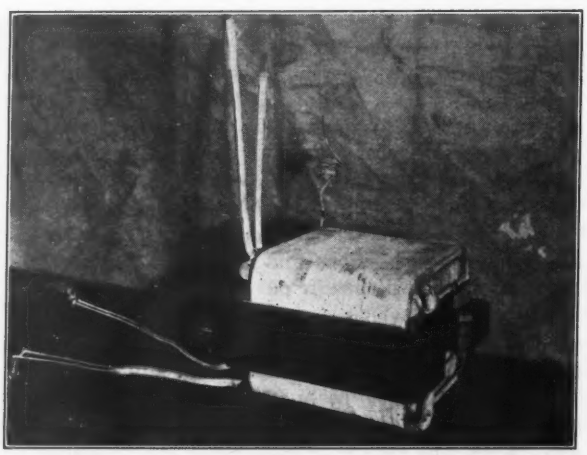


FIG. 1. MAGNETIC CIRCUIT PARTIALLY ASSEMBLED AROUND COILS OF STEEL CLAD TRANSFORMER. THE COILS ARE COMPLETED BEFORE THE STEEL IS BUILT UP

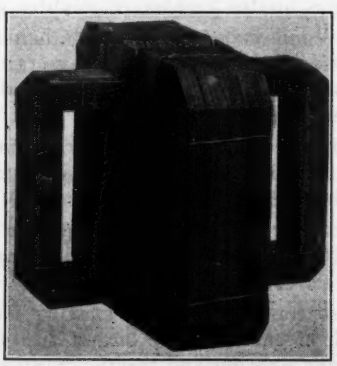


FIG. 2. MAGNETIC CIRCUIT OF STEEL CLAD TRANSFORMER WITH PATHS IN THEIR PROPER RELATIVE POSITION BUT WITHOUT COILS

it presents the mechanical difficulty that there is not sufficient space between iron circuits in which to bring out from the coils either a large number of leads or very heavy leads. The case of a transformer having many taps would therefore be a real problem, if it were not for the fact that we can omit one of the smaller iron circuits, and thus gain the necessary space. This would result in an approximate decrease in the area of the iron of twelve and one-half per cent, which would not interfere very largely with the ideal conception of the core. The floodlighting transformer mentioned above, because of the very heavy leads needed on the high current, low voltage secondary, would be built on this modified core. If both the high voltage and the low voltage coils have a large number of taps or leads, both of the small iron circuits may be omitted, the high voltage leads being brought out on one side, and the low voltage leads brought out the other. This latter becomes in effect the simple shell type of construction.

Methods of Changing Amount of Iron in Core

A relatively simple way of changing the amount of iron in a given circuit is to vary the thickness to which the laminations or punchings, as they are called, are

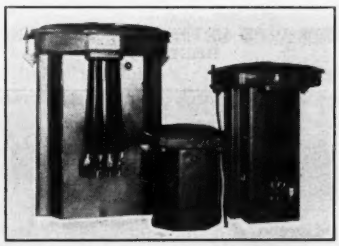


FIG. 3. GROUP OF STEEL CLAD, TYPE S TRANSFORMER

stacked. This method can be used in conjunction with all three of the cores mentioned above, obtaining a very close approximation of the desired area or weight of iron.

These standard parts, normally used for distribution transformers, can be readily employed in the construction of balance coils for d.c. generators, for series transformers, and for regulating transformers. The tanks into which these assembled punchings and coils are placed, offer an interesting example of standardization of parts. Any one of the above modified cores or types of apparatus of a given rating could be accommodated in the same tank. Figure 3 illustrates a group of these tanks of completed transformers.

The Core Type Transformer

For the relatively high distribution voltages, practice has shown that the core type of iron circuit is preferable. Here, as in the shell type of circuit, modification may be effected by changing the thickness to which the laminations are stacked. It is to be observed that in all these modifications of the original circuit the dimensions of the opening in the iron remain constant.

The core type, like the simple shell, is inherently suitable for designs having a large number of loads, or a few very heavy leads, coming from the coils. The versatility of the core type is shown as well as in its use with series

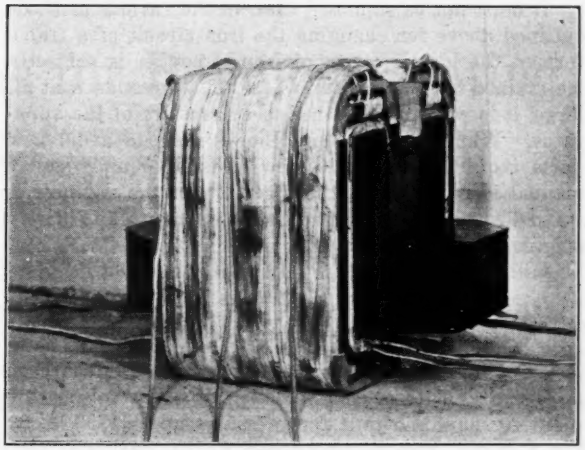


FIG. 4. CORE AND COILS OF A STEEL CLAD TRANSFORMER PARTIALLY ASSEMBLED

transformer intended for a line of comparatively high voltages, with reactors and with balance coils.

There remains to be considered the three-phase type of core for distribution transformers. What has been said of the core type regarding modification applies equally well to this circuit. An assembled core of this type is shown in 5. Modification consists entirely in varying the thickness of punchings or "built up" dimension. The three-phase core is less readily adaptable to other forms of construction and apparatus than the two previously mentioned.

It is to be observed that when making the modifications in cores as enumerated above, two important factors remain unchanged. In the first place, the ratio of the length to the width of the opening remains constant. This is a very important consideration, for the dimensions have been carefully worked out to give the most economic design possible. Secondly, the modifications are not such as to cause cross flux or a prohibitively large amount of flux in any part of the magnetic circuit. Cross flux is that which, due to a change in area of the path, must travel to a certain extent at right angles to the plane of the punching laminations.

FIG. 5. COILS AND IRON OF A THREE-PHASE TRANSFORMER AFTER IMPREGNATION

It must not be supposed that, in the various methods outlined above for changing the iron circuit of a transformer, the ideal relation of iron to copper is perfectly maintained but, in general, where the digression is at all large, it is warranted by the special nature of the apparatus. What has been done, however, is to avoid new parts requiring expensive new tools or equally costly manual labor. In this, the ingenuity of the engineer is taxed just as fully as would be the case with an entirely original design.

Pipe Fabrication

DEVELOPMENT of power systems in the southern states has resulted in erection of a new fabricating plant for handling pipe for pressures up to 1350 lb. by the General Fire Extinguisher Co. at Atlanta, Ga., whose product is sold through the Grinnell Co.

Besides large storage facilities and equipment for usual fabrication and testing of pipe and headers, the steel and concrete building with daylight construction houses departments for making lap joints and bends, with features of special interest, as seen in Fig. 1.

At the right are the furnace for end heating of pipe for lap joints and the lap joint machine. Furnace door flanges to fit the size of pipe and adjustable outside support ensure centering the pipe in the furnace so that it is evenly heated, giving square joints of uniform thickness. The joint machine, which will handle all sizes and weights up to 24 in. outside diameter and 40 ft. long, can upset the end to produce thickness required for any type of joint,—Sarlun, Sargol, tongue and groove or special groove facings,—with minimum finished thickness 100 per cent of the pipe wall. Rolls are driven by the motor on top, the pipe remaining stationary and rolls being forced against it by a hydraulic press ram.

For bending, pipes are filled with sand, the pipe resting vertically on a revolving table, Fig. 2 and being hammered by spring hammers which travel on the vertical tracks. Sand of special mix to prevent glazing or adhering to the pipe is carried from a pit below the floor through the vertical shaft to an overhead storage box, then fed by hose to the filling funnel, seen at the top of Fig. 2. This method insures full filling of the pipe.

After filling, the pipe is placed in the bend-heating furnace seen at the left of Fig. 1 in the background. The length to be bent is blocked off with fire brick at the ends, sections of top to cover this length closed down and a corresponding number of oil burners turned on. Properly heated, the pipe is transferred to the bending table in front of the furnace and formed to the desired shape. The sand filling prevents buckling, wrinkling and flat spots.

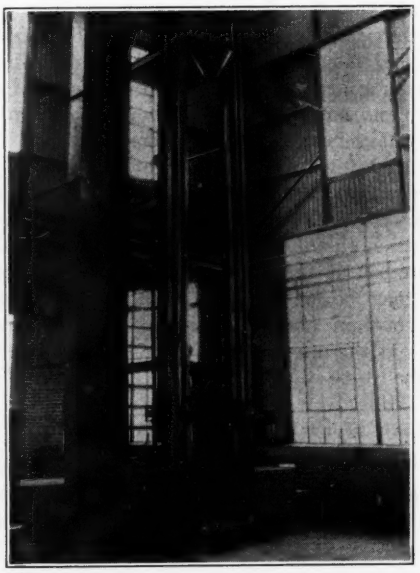


FIG. 2. HERE PIPE IS FILLED WITH SAND BEFORE BENDING

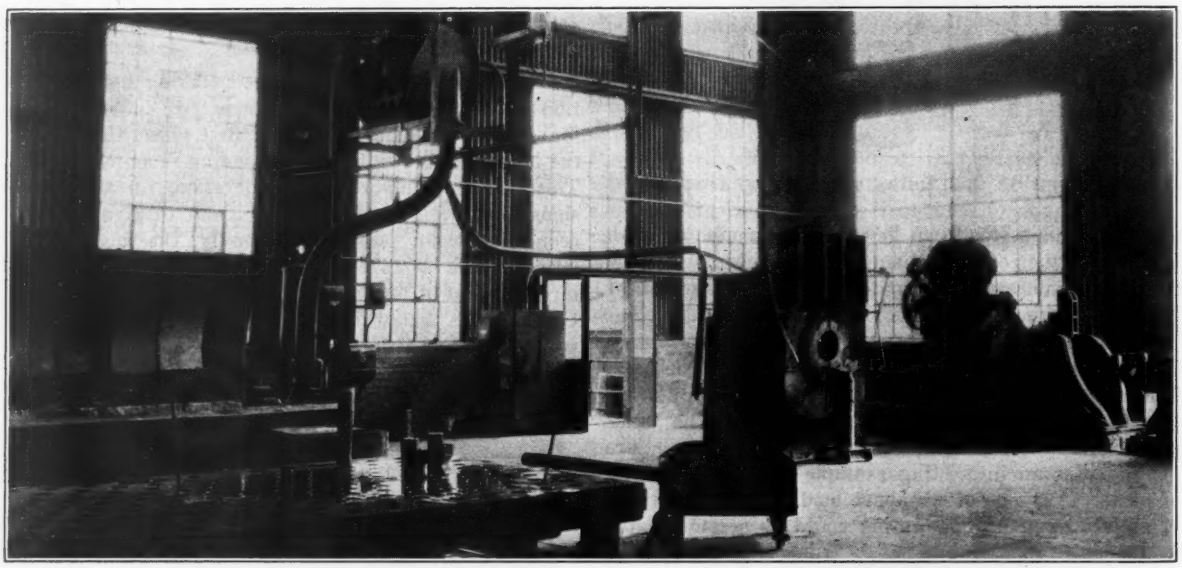


FIG. 1. FURNACES AND MACHINES FOR LAP JOINTS AND PIPE BENDING

Panel Warming Systems for Building Heating

PANELS IN CEILINGS, CONSISTING OF HOT-WATER COILS OR ELECTRIC HEATERS WITH LARGE SURFACE AT LOW TEMPERATURE, FIND MANY APPLICATIONS IN ENGLAND. BY L. J. FOWLER*

DURING his travels in over a dozen countries, the author has found that there prevails a popular belief that the Englishman spends his winter evenings in front of a large open fire in a room with fully opened windows. Such a state of affairs, although a libelous exaggeration of the actual conditions in a typical English home, presages an elementary but instinctive conception of the fundamental physiological principles making for the comfort of the human body. In surroundings at 64 deg. F., Rubner states that the mean surface temperature of clothes and exposed skin is about 75 deg. F. If the walls and ceiling of a room, however, are maintained at about 75 F., the mean radiation losses from the human body are almost nullified; and although the air temperature may be as low as 50 deg., bodily heat, lost only by convection, is easily balanced by the normal metabolism so that no discomfort is felt. These conditions pertain only to still air.

ACTION OF RADIANT HEATERS

Radiant heaters, such as open fires and luminous electric heaters, emit rays of varying intensities which, besides directly impinging upon the occupants, strike the walls, ceiling, floor and furniture of a room. A portion of this incident energy is absorbed and raises the temperature of the object which it strikes, eventually setting up convection, and a part is reflected one or more times before it reaches any of the occupants. With these forms of heater, it is conceded that not only is there excessive variation in comfort—and degree of discomfort—throughout the room, but the fuel or power consumption reaches an uneconomical figure.

Although the higher temperature radiant source is far from satisfactory, the heating of the whole of the walls and ceiling is not commercially possible. Over 20 yr. ago, Prof. A. H. Barker conceived the idea of the radiator (the word being used in the scientific and not the commercial sense) of comparatively large surface and comparatively low temperature. His patents were taken over and developed by Richard Crittall & Co., Ltd., to whose efforts is due the effective compromise called panel warming, in which large surfaces are warmed to a relatively low temperature which, at times, need not far exceed the 75 deg. of the ideal room. On occasion, the walls are warmed but this is not ideal for not only is convection set up but there is limitation to the positions in which heavy pieces of furniture may be placed without obstruction to the uniform distribution of heat. The modern practice is to install the warming surface—termed panels—in the ceilings.

CONSTRUCTION OF WARMING PANELS

The panels generally consist of coils of pipe through which water flows and the inevitable development of the principle to electrical power has been eminently successful. The pipes, usually of ½ or ¾ in. diameter, run parallel to each other at 4 to 6 in. centers and are embedded in concrete in the underside of the ceiling of the room to be heated. The surface of the concrete is then plastered, rendering the panel invisible. Heat is conducted from the pipes to the plaster face and is then emitted in radiant form. The surface temperature of the plaster is considerably lower than that of the water flowing through the pipes and is affected by their diameter and spacing. At the centers given, it is found that over the whole of the panel, the temperature varies little.

Practice shows, however, that the actual heat lost from warming panels is considerably in excess of that

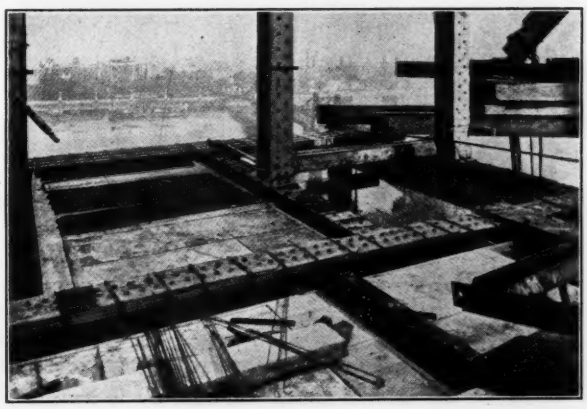


FIG. 1. WARMING PANEL ON FORMS READY FOR CASTING IN CONCRETE

expected. There are several reasons for this in a good installation, the most important being air movement. Another factor arising to explain the discrepancy between the theoretical and the practical emissions is the heat conduction upwards from the panel.

The panel system, as generally applied, is a low-pressure hot-water system, the circulation being either accelerated or by gravity in smaller installations. The distributing mains are designed similar to those of a radiator system.

PANELS USED WITH VARIOUS TYPES OF CONSTRUCTION

When a reënforced concrete floor is used, the coils are laid on the shuttering, or forms, and connected to the mains, which are usually run adjacent to the stanchions. Before delivery to the site, a works test is made at 500 lb. per sq. in. with compressed air under water but when the coils are connected to the mains, a hydraulic test of 250 lb. is applied for several hours before the concrete is cast.

The coils themselves are bent and welded electrically at the works, but all joints during erection are made by the oxy-acetylene welding process. The heating con-

*London, England. From a paper prepared for the 36th annual meeting of the A. S. H. & V. E. at Philadelphia, Pa.

tracts which were carried out simultaneously by one firm in London three years ago include 75 mi. of pipe necessitating 15,850 electric and 13,000 oxy-acetylene welds, all of which have been buried in concrete.

The value of a heating system at an early stage of the building construction is great for working conditions are improved for the operatives of other trades while drying out of concrete and plaster ready for the reception of joinery allows the progress of the whole construction to be advanced rapidly. In some cases, it is profitable even to install temporary boilers and mains to obtain this early heat.

Architectural Consideration

In most reënforced concrete or hollow tile constructions, the coils are cast in concrete in the soffit of the

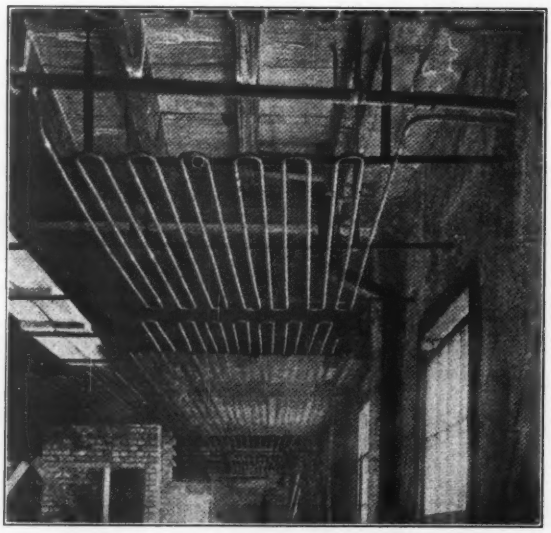


FIG. 2. WARMING PANELS APPLIED TO A HY-RIB CONSTRUCTION

floor over that which has to be heated. The temperature of the water gravitating or pumped through the system is not sufficiently high to set up expansion stresses which cannot be taken up by concrete without movement or cracking.

When the concrete is sufficiently matured, the ceilings are hacked, if no satisfactory constructional key has been provided, and plaster is applied according to a specification set out by the patentees of the system. If reasonable care is taken, the failure of plaster work in contact with panel surfaces maintained at the normal working temperature need not be feared and reputable plastering firms in England will give a five-year guarantee for work of this type.

Standard arrangements have been developed for incorporation of coils behind marble walls, floors or ceilings, behind terrazzo walls and floors, below wood joist floors and finally to existing ceilings, by means of special precast plaster slabs which contain the coils and which are finished in comformity with the decorations of the rooms in which they are fixed.

Electric panels of the Dulrae type are formed of a light asbestos sheet faced with cork, on which is placed a layer of plaster composition about ¼ in. thick, containing a grid work of specially insulated wire element, making a panel of a total thickness of about 1½ in. The panels are made in stock sizes, 36 by 12 in. and 72 by 24 in. and for various voltages up to 250; they can be operated by either direct or alternating current.

The most efficient method of control is by a thermostat operating directly or, when the load is great, through a contactor switch.

A compromise between the hot water and the Dulrae Panel is gaining popularity; heating elements are encased in sheaths of glass which are placed inside steel tubes, the space between the two being filled with a plaster material to permit ready conduction from one to another.

Power Consumption of an Electric Installation

By the courtesy of J. L. Musgrave and R. G. Crittall, to whose foresight and ingenuity and, above all, to whose fortitude, the development of panel warming is mainly due, I am enabled to give below some figures obtained on an electric panel installation in London during the severe winter of last year. The heating season was prolonged from October 1 to May 1, a period of 212 days, with an average recorded temperature of 43 deg. F. The building under test contained eight large rooms, hall, staircase and the like and by thermostatic control was maintained at 60 deg. F., at which temperature the radiant heat secured conditions of comfort. The total connected load of the electric panels was 20 kw. making 101,760 kw-hr. available throughout the 212 days. The actual power consumed was 30,300 units, approximately one third full load. The cube of the rooms warmed was 21,250 cu. ft., making a total of 1.42 units per foot cube—a moderate annual charge.

A northerly room of 3250 ft. cube equipped with 65 sq. ft. of heating surface gave an average daily consumption of 10 units for 24 hr. costing approximately one-third as much as a gas fire in an adjoining building.

Experience proved that panel warmed buildings are run with the minimum fuel consumption when they are maintained at even temperature throughout the winter.

The prime cost of a low pressure hot water panel installation exceeds by only a small margin that of a similar radiator system if the expense of enclosing and decorating the exposed portions of the radiator system is considered. Furthermore, the value to other trades of the early provision of heat to the unfinished building cannot be readily estimated but there is no doubt that in modern construction, in which speed is a paramount consideration, it definitely justifies increased expenditure on the heating system.

Accessibility, Expansion and Corrosion

The architectural virtue of invisibility is claimed by some to create an undesirable element. Unless the greatest care is taken in the preparation of accurately detailed record plans, difficulty may subsequently be experienced in locating the exact positions of pipes and alterations to the system are therefore difficult. These, however, are rarely necessary, for the reason given above. In a well-designed installation, sub-division by partitions is relatively unimportant.

Reference should be made at this point to expansion and corrosion. The coefficients of expansion of concrete and mild steel are 0.62×10^{-5} and 0.66×10^{-5} per degree F. respectively. Stresses set up in the concrete owing to the higher expansion coefficient of the steel, at the normal working temperature of 120 deg., are not sufficient in magnitude to cause failure or cracking.

Internal corrosion is not serious in a system where the makeup water is not great. Oxygen is slowly admitted through valves and the pumps in an accelerated circulation but experience does not show that the quantities are sufficient to be dangerous. The causes of external corrosion have to be studied by the steelwork and reënforced concrete contractors as well as the heating engineers. No trouble is experienced if the materials in which the pipes are encased are selected with care. It is important, however, to avoid any oxychloride compounds.

Panels Used with Heat Accumulator

In the last few years, remarkably even temperatures have been maintained in panel-warmed buildings in which the boilers have only been fired for about one-third of the day. During this period, the excess heat generated is circulated to large storage tanks, where the temperature of the water rises as high as 280 deg. F. under the head of the building. An automatic mixing valve, controlled by a thermostat fixed in the flow pipe, permits the water circulating through the system to be continuously maintained at the required temperature, generally between 90 and 120 deg. F. by mixing with it a proportion of water from the storage tanks, which gradually fall in temperature until the boilers are once more operated. In some installations, the storage tanks themselves are directly heated by thermostatically-controlled immersion heaters, which are operated on the night load by means of time switches.

Satisfactory results are also secured from the thermostatic control of individual rooms by solenoid-operated valves controlling the flow of water through the panel.

A further development of fundamental importance is the use of panel systems for cooling during summer months. Cooling water at a temperature of between 40 and 50 deg. F. is circulated through the pipes and only a slight lowering of room temperature is required. The cooled panel surface absorbs the heat radiated from occupants, walls, or floors and there is a definite absorption from convective currents which at the same time prevent condensation at the working temperature that is found desirable.

Corrosion in Centrifugal Pumps

Chemical, Mechanical and Electrolytic Changes Cause Severe Trouble at Times. By C. H. S. Tupholme

WHEN CORROSION OCCURS in a centrifugal pump, it is often impossible to determine the exact cause. Similar phenomena appear in hydraulic turbines where their effects are particularly evident at the extremities of the runner blades and at the tips of the guide wheels, while the casing and covers generally are less affected. The spots eaten away by this process of corrosion become porous and spongy and the work of destruction often proceeds at such a rate that only a short period of service is sufficient to render the corroded part absolutely useless.

Corrosion may be due to many different causes; it generally arises from chemical or electrolytic action or from combined chemical and mechanical action; in addition to that, the material may be eroded away by purely mechanical action, for example when the water contains sand.

Corrosion due solely to chemical action is found particularly in acid pumps when unsuitable kinds of material have been employed in their construction. The great majority of corrosion phenomena, however, are due to combined chemical and mechanical action on the material. Such cases occur when the water pumped contains a considerable quantity of air or other gases. The corrosive action can be explained in the following manner. Small air bubbles separated out from water adhere firmly to the material, and the oxygen contained in them combines with the metal. The water flowing over the affected part washes out the oxidized material, providing more favorable points for corrosion. This process of destruction is carried on continuously until the material is partly or wholly eaten away. If the material is impure or non-homogeneous, the action, of course, proceeds more rapidly. The more resistant metals, a good bronze for example, oxidize much less readily than iron.

High Velocity and High Vacuum Favor Corrosion

One factor which favors corrosion is a high suction head, the greater the vacuum, the more air is freed from the water. If there is carbonic acid present, rapid destruction of the metal is unavoidable. If the water is flowing at a high speed, this also accelerates corrosion. It is for this reason that the greatest corrosion is found at the extremities of the impeller blades and at the tips of the guide wheels. Eddy currents, produced where the water passes from the impeller into the guide wheel increase the danger of corrosion. In multi-stage pumps, it is, as a rule, only suction-side of the first impeller that is attacked, while those in the following stages remain practically unaffected. The explanation of this phenomenon can only be that there is a certain vacuum at the inlet to the first impeller and that this causes air to separate out from the water. Other impellers work under a certain pressure so that no air is separated out from the water they handle. Corrosion of this kind is not as a rule found in pumps to which water flows under pressure.

One effective means of avoiding or eliminating corrosion is to fit an air chamber with air separator before the pump, the air liberated being removed by an ejector or air pump. Otherwise the pump can be installed,

when this is possible, at such a level that the water enters it under pressure.

Electrolytic Action Is Less Common

Less common, but just as dangerous, is corrosion caused by electrolytic action. This type of corrosion is found mainly in pumps handling water containing acids or salt. All conductors of electricity can be arranged in a certain order, the so-called contact series, in which the precious metals stand at one end and the commonest at the other. Without considering all the members of the series, the following is the order of a few metals: Magnesium, aluminum, zinc, iron, tin, nickel, copper, silver. Two different metals in the series constitute a galvanic element when dipped in an acid, basic or salt solution, and the difference of potential is the greater, the farther the metals are apart in the series. In addition to that, the difference of potential depends on the liquid in which they are placed.

If the two metals are directly connected with each other at a point, a short-circuited galvanic element is formed and a current starts flowing, which, according to Ohm's law, is directly proportional to the difference of potential and inversely proportional to the resistance of the circuit. In addition to the metals, the liquid in which the metals are immersed acts as a conductor of current. The direction of flow of the current through the liquid is always from the less precious metal, the so-called negative element, towards the more precious electro-positive metal; and in the outer circuit it flows from the positive to the negative pole.

Metals forming the galvanic element are at the same time subject to chemical decomposition. If an electric current flows through a conducting liquid of the kind mentioned above, the chemical changes which take place cause the molecules of the liquid to decompose and the resultant products separate out and are deposited on the metal plates. In many cases, oxygen and hydrogen are produced, the former at the positive pole of the cell and the latter at the negative pole. If the liquid contains a chloride salt, ordinary salt for instance, chlorine is generated at the positive pole and hydrogen at the negative. The chlorine produced in this manner is much more corrosive to metal than chlorine produced by a purely chemical process. The combination it forms with metals are soluble in water. The hydrogen, on the other hand, acts as a reducing agent and acts as a protection to the metal on which it collects.

Action Depends Upon Metals Used

Of the two metals forming the elements of a cell, that one forming the negative pole, is chemically decomposed. If, for example, a vessel contains a solution of ordinary salt, and two plates, one of iron and the other of copper, the iron plate will be eaten away by chlorine while the copper plate will be kept bright by hydrogen. Iron alloys, as for example grey cast iron, behave similarly to iron, except that the graphite particles are not decomposed, since they are practically resistant to chemical action and play much the same part as copper after chemical action has started.

On the other hand, no galvanic element is formed when both electrodes of the cell are made of the same material. Any decomposition then occurring can only be due to pure chemical action and is much less severe. When the different metals, say bronze and cast iron, can be fitted tightly together as when both are turned in a lathe, no electrolytic action takes place.

Vertical Compound Unit for P. G. & E. Co.

New type of vertical compound turbine-generator is shown being erected for test in the Schenectady Works of the General Electric Co. The 1200-lb. high-pressure turbine and generator are mounted on top of the generator of the low-pressure element. The pictures show the first of the two 50,000-kw. turbine generators for the

SHOP VIEW OF VERTICAL COMPOUND UNIT

Pacific Gas & Electric Co., San Francisco. The steam conditions are 1200 lb., 750 deg. F. total temperature, boiler reheat to 750 deg., and 1¼ in. absolute back pressure.

High Pressure Flow Meter

In the article under the above title, page 474, April 15 issue, the illustration of the meter is incorrectly shown. The top of the meter is at the right of the cut as it now appears.

By international agreement, the quantity of electricity which deposits 0.001118 grams of silver is one coulomb and the current which deposits this amount of silver in one second is one ampere. The ohm is the resistance at 0. degree C. of a column of mercury 106.3 cm. long weighing 14.4521 grams and of uniform cross section (about 1 sq. mm.) and the volt is the electromotive force needed to drive a current of 1 ampere through a resistance of one ohm. Upon these definitions is based our entire quantative electrical system.

Battelle Memorial Institute, Columbus, Ohio, announces the addition to its staff of Ralph A. Sherman to direct the program of research on combustion. For the past 10 yr., Mr. Sherman has been fuel engineer with the Pittsburgh Experiment Station of the U. S. Bureau of Mines, where he conducted investigations and published numerous reports on combustion problems.

Extent of Permissible Monopoly in Patents

Review of Present Laws and High Court Decisions Involving the Rights of Patentees. By Leo T. Parker*

INCORRECT and unreliable information appertaining to the present day rights of patentees to restrict the resale prices and uses of patented things is current among engineers, as well as manufactures and sellers of merchandise. The reason for this general misinformation is that the laws on this subject have undergone a gradual revision during the past several years and naturally the average man has had neither the time, opportunity nor inclination to keep informed of the various changes that have occurred.

Therefore, the purpose of this article is thoroughly and practically to review the present important laws and leading higher court decisions which have involved the monopoly of patents and the rights of patentees to control the uses of their inventions, fix resale prices and impose license restrictions. In this manner, many persons who are possessed of incorrect information regarding patents will understand the interpretation of the present laws on these subjects. Also, in many instances, the important points of the courts' opinions will be cited so that the reader will be assured of obtaining first-hand information.

First, it is interesting to observe that an absolute property right in patents has been generally recognized by all courts since the patent laws were formulated. In the very old higher court case (Wilson v. Roesseau, 4 How. 646) it was said:

"The law has thus impressed upon it (patent) all the qualities and characteristics of property and has enabled him (inventor) to hold and deal with it the same as in the case of any other property belonging to him, and on his death it passes, with his personal estate, to his legal representatives, and becomes part of the assets."

Reasons for Patent Monopoly

In the old and ancient litigation of Pennock v. Dealogue, 2 Pet. 1, decided in 1829, the court clearly explained the primary purpose of patent monopoly. The later courts have consistently upheld this court's interpretation of the law, as follows:

"While one great object of our patent laws was, by holding out a reasonable reward to inventors, and giving them an exclusive right to their inventions for a limited period, to stimulate the efforts of genius..... the main object was to promote the progress of science and useful arts."

The present laws of the United States give a patentee the exclusive right to control the *manufacture, use and sell* his patented invention. If he prefers he may withhold its benefits from all persons and prevent all persons and firms from making, selling and using the invention. In the leading case of Heaton Peninsular Co. v. Eureka Specialty Co., 47 U. S. 146, the Supreme Court of the United States explained this phase of the law, as follows:

"If he (patentee) sees fit, he may reserve to himself the exclusive use of his invention or discovery..... That the grant is made upon the reasonable expectation that he will either put his invention to practical use or permit others to avail themselves of it upon reasonable terms, is doubtless true. This expectation is based alone upon the supposition that the patentee's interest *will induce him to use, or let others use, his invention..... His title is exclusive* and so clearly within the constitutional provisions in respect of private property that *he is neither bound to use his discovery himself nor permit others to use it.*"

Right to Restrict Use

At various times during the early periods of the industrial progress in the United States, the question has frequently been presented to the courts whether or not a patentee has a monopoly of such character that he may legally control the uses to which purchasers of his invention may subject it.

The enactment of the Sherman Anti-Trust Act in the year 1890 resulted in numerous patent litigations, because many purchasers of patented articles contended that this Act affected the previously recognized broad monopoly in patents. Then several years later the Clayton Act importantly modified the previous monopoly afforded inventors by patent rights.

The Supreme Court of the United States, in the case of Bauer v. O'Donnell, 229 U. S. 1, established a new law presently effective on the rights of a patentee to control the resale price of his patented product.

In this case, it was disclosed that each patented article, had attached to it a notice that the dealer who purchased it from the manufacturer should resell the device for not less than a stipulated amount.

The patentee contended that this notice was valid and enforceable against all purchases because it constituted a legal agreement made when the sale was completed.

In holding a patentee not legally entitled to control the resale prices of his product, however, the Supreme Court of the United States explained the new law on the subject saying:

"The (patent) act secured to the inventor the *exclusive* right to make, use and vend the thing patented, and consequently to prevent others from like privileges without the consent of the patentee. The patented article in the language of the court, passes without the limits of the monopoly; that is to say, the patentee or his assignee having in the act of sale received all the royalty or consideration which he claims for the use of his invention, in that particular machine or instrument, it is open to the use of the purchaser without further restriction on account of the monopoly of the patentees."

The same law is effective with respect to the right of a patentee to control or restrict the uses of a patented invention that is sold outright to a user. The Supreme

*Attorney-at-Law, Cincinnati, Ohio.

Court of the United States held that a contract of this nature is invalid, saying:

"The real question is whether in the exclusive right secured by statute to 'vend' a patented article there is included the right, by notice, to indicate the price at which subsequent sales of the article may be made. But, in the essential nature of things, when the patentee, or the person having his rights, sells a machine or instrument whose sole value is in its use, he receives the consideration for its use, and he parts with the right to restrict the use."

License Agreement

Engineers, however, should not confuse the right of a patentee to restrict the uses of patented articles distributed under a license agreement, instead of outright sale. In other words, a license user is bound to abide by the reasonable terms of a license contract by which the patentee agrees for a stipulated sum to permit the licensee to use a particular invention for specified purposes in a limited territory.

Under these circumstances, the patentee receives remuneration in accordance with the rights granted the licensee and the latter is bound to abide by the agreement. A license contract, however, may be invalid for many reasons. For example in a recent case (226 U. S. 20) the Supreme Court of the United States held that where a patentee enters into an agreement by which the *output* of a patented product is controlled, such an agreement is illegal under the Sherman Anti-Trust Law.

Also, a license agreement is invalid by which a patentee seeks to eliminate competition. For instance, in a recent case (258 U. S. 451) it was disclosed that a manufacturer included in a license contract a stipulation obliging the licensee user of the machines not to use machines made and sold by competitive manufacturers. The court held this contract void and of no effect, in view of the provisions of the Clayton Act, and said:

"No matter how good the machines of the company may be, or how efficient its service, it is not at liberty to lease its machines upon conditions prohibited by a valid law of the United States. From an early day, it has been held by this court that the franchise secured by a patent consists only in the right to exclude others from making, using, or vending the thing patented without the permission of the patentee.....The patent grant does not limit the right of Congress to exact legislature not interfering with the legitimate rights secured by the patent but prohibiting in the public interest, the making of agreements which may lessen competition."

Moreover, lease contracts which legally are contracts of sale, will not enable patentees to restrict the purchaser's uses of the invention.

For illustration, an agreement by which a purchaser contracts to pay the seller stipulated amounts at specified periods, with the privilege of purchasing the machine upon completion of the installment payments for an insignificant amount such as $1.00, is legally a sale contract and not a lease contract.

Therefore, users of patented machines purchased under this, or similar forms of contracts, are not bound by agreement restricting the uses or resale prices of the patented devices, because, as previously explained, a patentee cannot control the uses to which his invention is put after he has sold it.

For instance, in a recent case (113 So. 454) a higher court held that a valid straight contract of sale may not be changed to a conditional contract of sale simply because the contract is worded to accomplish this purpose.

The facts are that a buyer and seller signed a contract which purported on its face to be a lease, but which was held to be a sale. By its terms, the buyer agreed to lease from the seller for the term of 12 months, a certain machine. The buyer was to pay a total rental of $4500, the first payment of $450 at once and the balance was to be paid in equal installments.

An important part of the agreement was that delivery of the special machine should be made f.o.b. Chicago on or about June first. The seller agreed to install the machine and it was stipulated that the contract should not be considered binding until the payment of the $450, on May first. It was also agreed that the buyer should pay the taxes on the machine while it was in his possession, and that, at the expiration of the 12 months' period, he should return the machine to the seller in good condition, or should have the option of purchasing it for $1.00, instead of returning it, provided he had complied with all the provisions of the lease.

Later litigation arose and the court in holding this form of contract to be an outright sale instead of a lease, said:

"The first question to be considered is the nature of the contract out of which this litigation grows. The contract, though couched in the phraseology of a lease, is in fact a sale. It contains the essentials of a sale, to wit, a fixed price, which was the rental to be paid, a thing to be conveyed and the consent of the parties to the conveyance at the price fixed. The contract, we think, clearly shows that what is designated as the rental to be paid for the use of the machine, for the period of one year, is, in fact, the purchase price to be paid for it and represents the full value of the machine .....It is inconceivable that the contract in question would have been entered into upon any other theory than that the $4500 was the amount to be paid for the ownership of the property, and not for the rental, and that the $1 consideration was a mere fictitious consideration, which it was never intended should be paid. The form of the instrument in such transactions is of little account in determining its nature. Hence, where the instrument, although written in the form of a lease, clearly shows that it was the intention of the parties to effect the transfer of the ownership of the property for a fixed price in money, denominated by them as rental or hire, the transaction will be deemed a sale and not a lease."

Michael Faraday, the son of an English blacksmith, was born in London in 1791 and died in 1867. He was a chemist by profession and his discoveries in electricity and magnetism form the basis of our modern electrical science. Oersted, a Danish physicist, discovered the relation between electricity and magnetism in 1819.

Most of the power in this country is produced from bituminous coal.

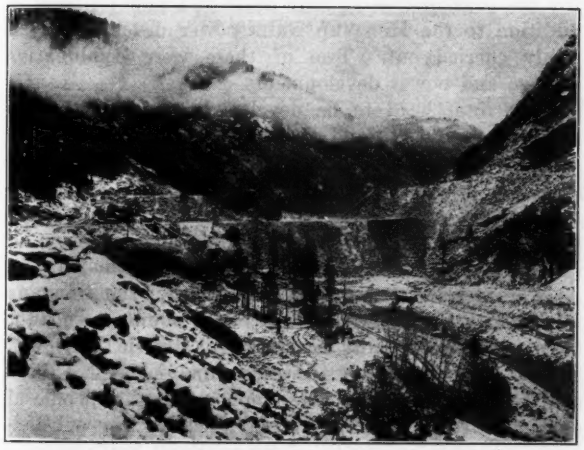
MOKELUMNE RIVER

AS THE BASIC UNIT of the Pacific Gas & Electric Co.'s extensive hydroelectric development of the Mokelumne River, the Salt Springs project is well under way and although not scheduled for completion until the middle of 1931, the dam has already taken definite form.

This dam, 328 ft. high, 1300 ft. long and 15 ft. wide at the crest and 960 ft. thick at the base, will contain approximately 3,000,000 cu. yd. It will be the largest rock-filled dam in the world, taking the record from the Dix Dam in Kentucky by a considerable margin. A concrete cutoff wall, 250 ft. long, 15 ft. deep and 6 ft. wide, extending into rock 40 ft. below the river bed will prevent seepage. This wall is continued up each end of the dam, tying it with both walls of the canyon.

Granite rock from adjacent cliffs is being used in the construction. The upstream face will consist of a 15-ft. thickness of derrick-placed stones, tightly packed with smaller rocks and covered with a concrete facing, tapering from 3 ft. thickness at the bottom to 1½ ft. at the crest. The reservoir will extend upstream 6 mi. and have a capacity of 130,000 acre ft. from which 15,000 hp. will be developed.

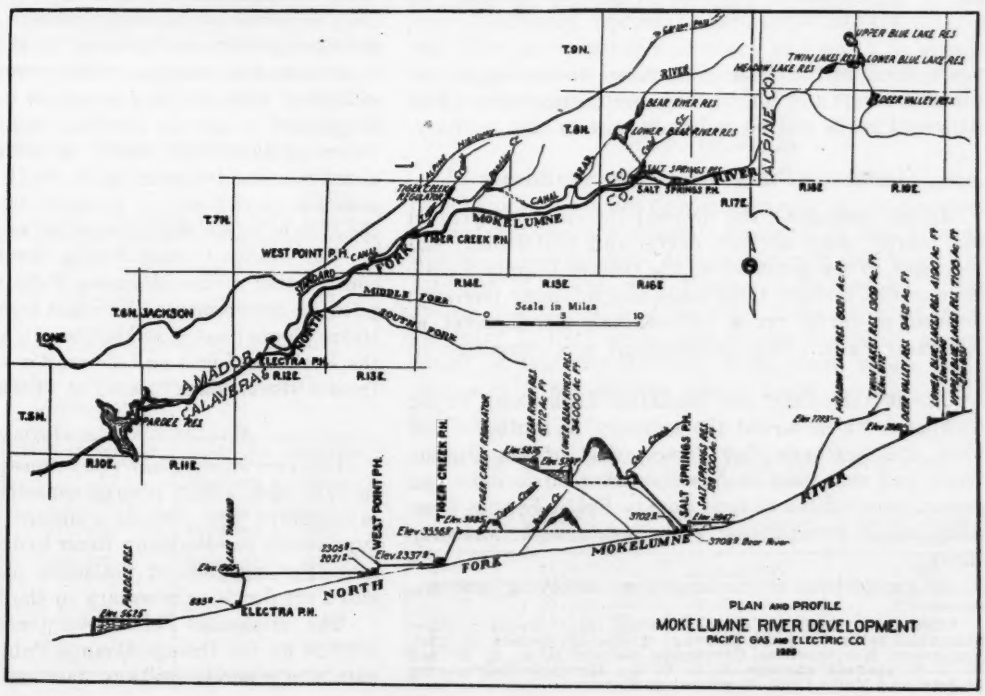
This is the first unit of a development program calling for



five different power plants with an installed capacity of 228,000 hp. on the north fork of the Mokelumne River near Jackson, Cal. The location is about midway between Yosemite National Park and Lake Tahoe and the entire development will be completed by 1934.

Water from the Bear River project will be carried through the mountains by a 2½ mi. pressure tunnel and a 1-mi. steel penstock to a 33,000-hp. unit in the same building that will house the Salt Springs unit. Another project, for which two 36,000-hp. units have already been authorized, at Tiger Creek will receive water from the Salt Springs and Bear River reservoirs through about 10 mi. of flume and tunnel.

From Tiger Creek power house the water will flow another 5 mi. to the West Point development where an additional 20,000 hp. will be generated, and from here 13 mi. farther to Lake Tabeaud now acting as forebay to the Electra power house which has played an important part in the San Francisco power supply since 1902. A new power house at Electra will add 80,000 hp. to the sum total of power development of the Mokelumne River.



Mongaup River Hydroelectric Development

IN SOUTHERN NEW YORK STATE THE ENTIRE WATER POWER OF A RIVER HAS BEEN DEVELOPED IN A SERIES OF PLANTS BY THE ROCKLAND LIGHT & POWER CO. BY WILLIAM F. UHL*

MONGAUP RIVER rises on the southwestern slope of the Catskill Mountains in New York and flows southerly to join the Delaware River about five miles west of Port Jervis. Its total drainage area amounts to about 220 sq. mi. with a total fall of about 600 ft. in the lower 18 mi. of river.

The industries and agriculture which at one time prospered on this river have gradually disappeared during the last century, although traces of old dams, mill and tannery sites, as well as scattered farm buildings, still remain. During recent years, the drainage area of the Mongaup River has almost entirely reverted to a wild and timbered state.

The distance from the lower reaches of the river to New York City is only about 60 mi., and during recent years, much of the drainage area has been occupied for summer camps and for hunting and fishing clubs. Few improved roads and no railroads exist in this territory.

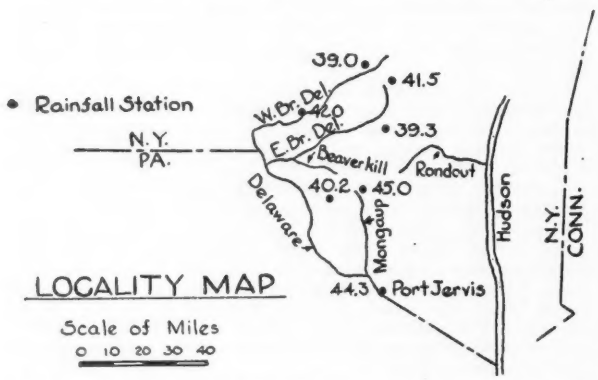


FIG. 1. MAP SHOWING RELATIVE LOCATION OF MONGAUP RIVER, WITH PRECIPITATION FIGURES

INCREASED DEMAND FOR ELECTRIC POWER

In the meantime, the demand for electric power in the nearby cities of Port Jervis and Middletown had increased to the point where the Orange County Public Service Co., serving these cities and adjacent territory, decided to carry out a hydroelectric development at Mongaup Falls. This development was completed in 1923.

About this time, the Rockland Light and Power Company, which served the territory in southern New York and northern New Jersey, west of the Hudson River and centering on Nyack, with electric light and power, acquired the Orange County Public Service Company and its ownership of water rights on the Mongaup River.

A comprehensive investigation, involving surveys, borings, load studies and preliminary designs and estimates, was undertaken by Charles H. Tenney & Co., managers and engineers of the Rockland Light and Power Co., to determine the physical feasibility and economical aspects of the situation. These investigations convinced them that a plan of development could be worked out which would fit in with the growth of the company's load.

FIVE DAMS FOR DEVELOPMENT

The plan for developing the Mongaup River that was finally worked out, as a result of power demand studies, surveys, borings, and estimates of cost, called for the construction of four dams and power plants in addition to the Mongaup Falls power development already carried out. Two of these were combination storage and power developments.

The total head to be developed by the five dams amounts to 735 ft., and the storage made available by the two storage dams amounts to 2,800,000,000 cu. ft. Each of the three power dams also provides a substantial amount of pondage, so that the flow of the river can be regulated for daily and monthly variation of load as well as for seasonal variation in stream flow.

Figure 1 shows the relative location of the Mongaup River with respect to the adjacent country and the territory the company serves with electric light and power. Figure 2 shows the location of the five dams and related parts of the developments and a profile of the lower reaches of the river, indicating the substantially complete utilization of the available head.

The names of the developments and principal data concerning them are shown in Table I.

Stream flow, storage, pondage and load factor studies indicated that the four proposed developments should be planned to have an installed capacity as shown in the following table, and should be ready for operation at about the time indicated in Table II. With these developments carried out as planned, it was estimated that the system load could be supplied as shown in Table III.

The Orange County Public Service Co., prior to its construction of the Mongaup Falls plant in 1923, supplied its requirements of electric current from two small steam plants located at Middletown and Port Jervis and the Rockland Light and Power Co. obtained its current from a steam plant located at Hillburn.

MONGAUP FALLS DEVELOPMENT

Hillburn steam plant was reconstructed and enlarged in 1927 and, with a present capacity of 15,000 kv-a., it is estimated will provide sufficient stand-by service to supplement the Mongaup River hydro developments and make the operation of the steam plants at Middletown and Port Jervis unnecessary in the future.

The Mongaup Falls development, carried out in 1922-23 by the Orange County Public Service Co., consists of a concrete spillway dam and intake built at the

*Hydraulic Engineer, Chas. T. Main, Inc. From a paper presented before a joint meeting of Boston Society of Civil Engineers, Northeastern University section B. S. C. E. and M. I. T. student chapter A. S. C. E.; Harvard Engineering Society and Tufts Civil Engineering Society.

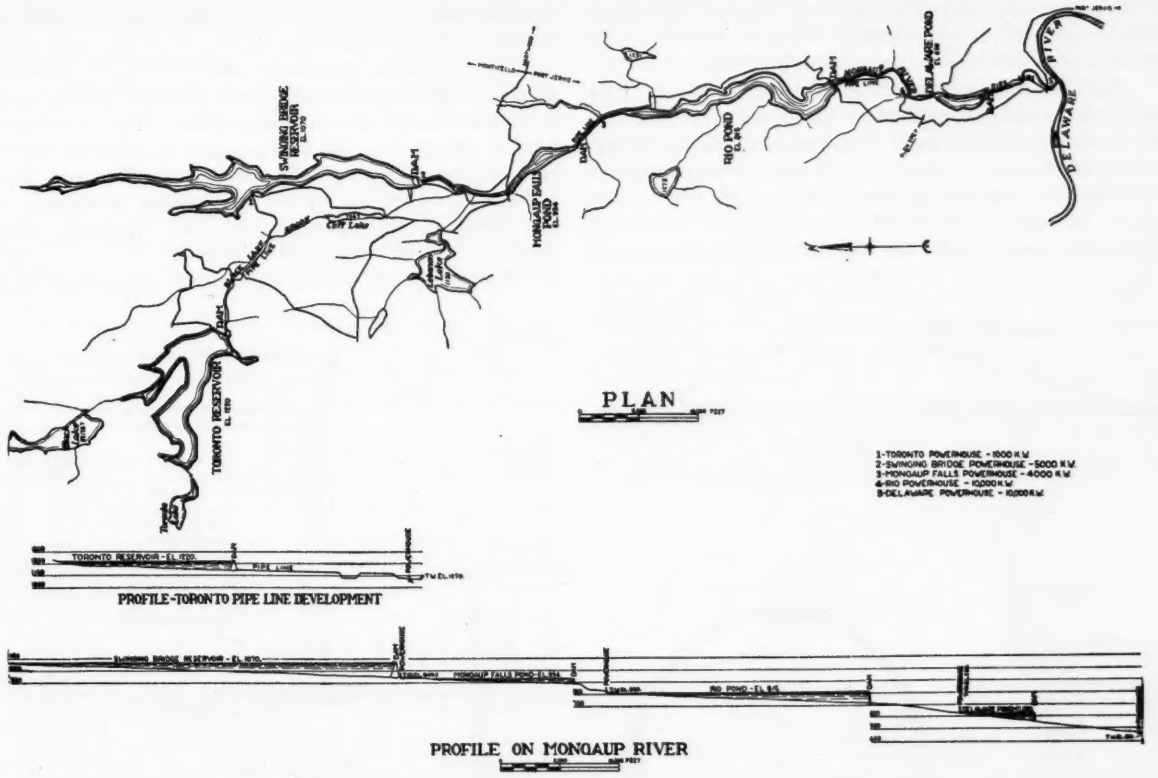

PLAN
1-TORONTO POWERHOUSE - 1000 K.W.
2-SWINGING BRIDGE POWERHOUSE - 5000 K.W.
3-MONGAUP FALLS POWERHOUSE - 4000 K.W.
4-RIO POWERHOUSE - 10,000 K.W.
5-DELAWARE POWERHOUSE - 10,000 K.W.
PROFILE-TORONTO PIPE LINE DEVELOPMENT
PROFILE ON MONGAUP RIVER

FIG. 2. GENERAL PLAN AND PROFILE OF MONGAUP DEVELOPMENT

crest of Mongaup Falls, the only natural falls of any importance on the river. This dam is of gravity type, built on rock between rock abutments. Its height of about 40 ft., with flashboards 4 ft. high, creates a pond having a surface area of about 120 acres and a volume of 70,000,000 cu. ft. A total gross head of 116 ft. is made available by means of the dam and a wood stave pipe line 8 ft. in diameter and 2650 ft. long.

The wood stave pipe line terminates in a simple plate steel surge tank 26 ft. in diameter and 106 ft. high. A short steel penstock with four successive branches leads from the surge tank to the four power units located in a power house on the bank of the river about 2700 ft. below the dam. Each of the four power units is rated to deliver 1650 hp. under 110 ft. net head. The turbines are of the single-runner, vertical, plate steel spiral type, and each is direct connected to a 1250-kv-a. vertical, 2300-volt, 3-phase, 60-cycle generator running at 360 r.p.m. The power generated in this plant is transformed to 33,000-v. current in an outdoor substation having four 1250 kv-a., 3-phase transformers and transmitted east into the company's territory and north to supply the Associated Gas and Electric Co.'s distribution system centering on Monticello.

TABLE I. MONGAUP DEVELOPMENT DATA

Plant	Drainage Area in Square Miles	Head in Feet	Kilowatt Capacity	Million Kilowatt Hours Yearly Output	Million Cubic Feet in Reservoir or Pond
Toronto	25	150	1,000	5	1,200
Swinging Bridge	118	125	5,000	15	1,600
Mongaup Falls	161	115	4,000	20	70
Rio	195	185	10,000	32	650
Delaware	207	160	10,000	35	100
Totals		735	30,000	107	3,620

TABLE II. CAPACITY OF PLANTS AND DATE OF OPERATION

Name of Development	Kilowatt Capacity	Ready for Operation
Toronto Storage		February 1, 1926
Mongaup Falls	1,000	February 1, 1926 (fourth unit)
Rio	10,000	November 1, 1927
Swinging Bridge	5,000	October 1, 1929
Delaware	10,000	November 1, 1931
Toronto Plant	1,000	November 1, 1932
	27,000	
Mongaup Falls	3,000	Completed in 1923
Total	30,000 Kw.	

Toronto Reservoir

In accordance with the plan of development established from the studies previously made, the first project carried out by the present company is the Toronto Reservoir, created by a dam constructed just below the junction of Black and Toronto Lake brooks. This project was started in June, 1925, and completed about February 1, 1926, or in time to store the 1926 spring runoff, so that the Mongaup Falls plant, which up to then was a run-of-river plant, could be more fully utilized.

TABLE III. POWER AVAILABLE FOR SUPPLYING GROWING SYSTEM LOAD

Year	Kilowatt-hours, Water Power	Kilowatt-hours, Steam Power	Kilowatt Steam, - Peak Load
1927	24,380,000	25,610,000	8,700
1928	42,690,000	14,680,000	1,600
1929	45,180,000	20,910,000	3,900
1930	64,410,000	11,410,000	4,600
1931	71,020,000	16,260,000	5,600
1932	91,380,000	8,540,000	0

The Toronto dam, Fig. 3, is of the earth-fill type, constructed by the hydraulic sluicing method. Its maximum height above stream bed is 90 ft.

The water released from Toronto Reservoir now flows into the Mongaup River about 2500 ft. south of the Swinging Bridge dam. Upon the completion of this dam it is planned to divert the Toronto Reservoir water into the Swinging Bridge Reservoir by a pipe line about 14,500 ft. long and 4 ft. 8 in. in diameter, at a point about three miles above the dam creating that reservoir, so that the Toronto storage may be utilized in all the plants on the river.

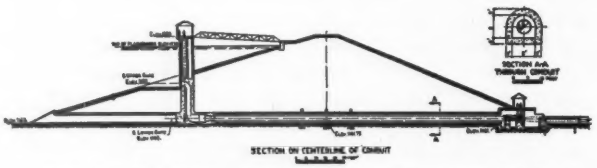


FIG. 3. SECTION OF TORONTO RESERVOIR DAM

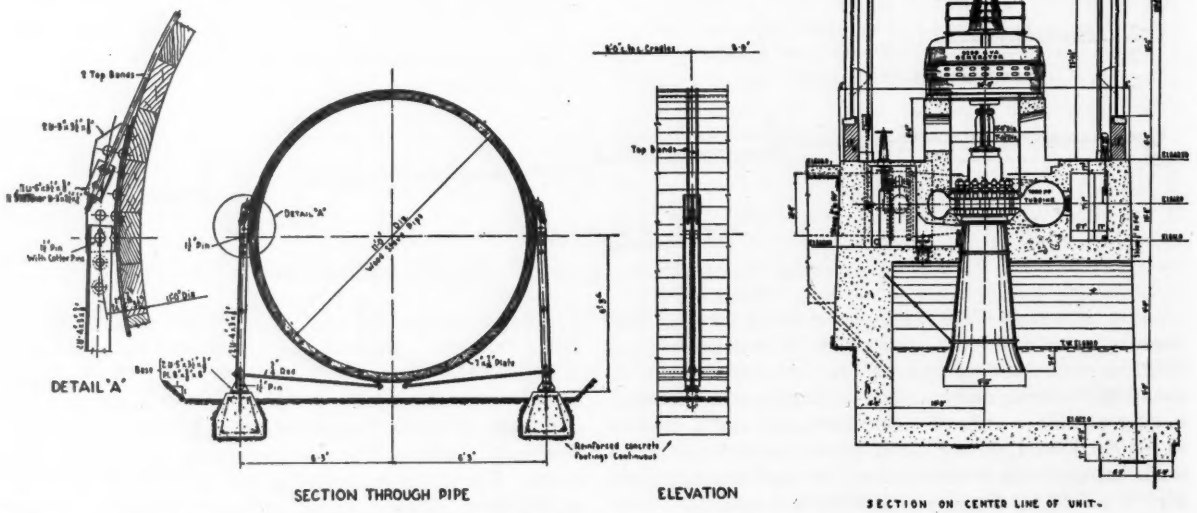
A 1000-kw. hydroelectric unit located at the outlet of the 4-ft. 8-in. pipe line will add about 5,000,000 kw-hr. to the yearly output of the system. It is planned to divert all of the Toronto storage into the Swinging Bridge Reservoir during the last six months of each year, and the pipe line and power unit are designed to provide sufficient capacity to accomplish this.

Rio Development

Early in 1926, construction work was started on the projected Rio hydroelectric development and this was completed in the fall of 1927. This development, located about four miles below the Mongaup Falls power plant, consists of a gravity type concrete spillway dam with concrete and earth-fill embankment abutments, a 7000-ft. long and 11-ft. diameter wood stave pipe terminating in a differential surge tank of 65 ft. high and 40 ft. in diameter, a plate steel penstock consisting of 380 ft. of 10 ft. diameter pipe with a wye, and two 110-ft. lengths of 7-ft. pipe supplying two 7000-hp. units located in a concrete and brick power house, short tailrace and an outdoor step-up substation.

The hydraulic machinery consists of two 7000-hp. single runner, plate steel spiral, vertical turbine units with plate steel conical draft tubes. The total static head is 185 ft. and the turbines are designed to deliver rated capacity under 170 ft. net head at 360 r.p.m. Each turbine is controlled by an oil-pressure governor. At the inlets to the spirals, 6-ft. 6-in. diameter motor operated butterfly gates are provided.

The generators are of the vertical type with direct connected exciters, and are rated at 6250 kv-a., 4000 v., 3-phase, 60 cycles.



FIGS. 4 AND 5. FIG. 4 (LEFT): FLEXIBLE CRADLE FOR WOOD STAVE PIPE, AS USED ON RIO AND DELAWARE DEVELOPMENTS. FIG. 5 (RIGHT): CROSS-SECTION OF RIO POWER HOUSE

Swinging Bridge Development

In September, 1927, the projected Swinging Bridge storage and power development was begun, and it was planned to complete this by September 1, 1929.

The dam is an earth-fill embankment, located about three miles above the Mongaup Falls plant. It has a maximum height of 135 ft. The reservoir created by this dam will be 7 mi. long and will flood about 1000 acres.

The power house will contain one 7000-hp. single runner, plate steel spiral, vertical turbine, direct connected to a 6250-kv-a., 4000-v., 3-phase, 60-cycle, 300 revolutions per minute generator with direct connected exciter. The turbine will be of special design, which provides a cylinder gate in addition to the usual wicket gates. The switchboard equipment will provide for the manual control of the plant by an operator, as well as for the remote automatic control from the Mongaup Falls station about 3 mi. distant.

Under normal conditions of operation, this unit will carry peak loads, the Mongaup Falls plant next downstream being operated as a base load plant.

A single circuit, 66,000-v. transmission line will connect this station with the central switching station at Mongaup Falls.

Delaware Development

It is expected that construction work on the projected Delaware development will be started early in 1930 and that it will be ready for operation in the early fall of 1931.

The dam site is located about a mile below the Rio power plant. The Delaware power house will be located on the west bank of the Mongaup River about 1000 ft. upstream from the confluence of the Mongaup with the Delaware.

The natural fall in the lower 1000 ft. of the Mongaup River is about 15 ft. This section of the river will be excavated to such depth and cross section that it will serve as a tailrace between the power plant and the Delaware River, fully utilizing the available fall in the Mongaup at this point. The total gross head developed will be 160 ft.

A 12-ft. wood stave pipe line 5600 ft. long will connect the intake at the dam with a differential surge tank located a short distance upstream from the power house.

A riveted plate steel penstock joins the wood stave pipe a short distance above the surge tank; this penstock will be 11 ft. in diameter with two branches, each 7 ft. 6 in. in diameter leading to two 7000-hp. turbines.

To increase the length of the spillway as much as possible without excessive cost, it was decided to locate the intake structure below the dam at the east bank. A pipe is carried through the dam to the intake tower, where the racks, intake gates and hoists are located. The details of this will be similar to the Rio intake.

The pipe line will follow the east bank of the river for a distance of about 3000 ft., where it will cross to the west bank on a trestle across a curve in the river. From this point, it will be carried across a flat area in a nearly direct line to the surge tank located about 1500 ft. from the Delaware River. The wood stave pipe line will be carried in flexible cradles supported on concrete footings similar to those used for the Rio pipe line, Fig. 4.

The power house to be located on the west bank of the Mongaup River will have the two 7000-hp. turbines with butterfly gates; these, with some of the auxiliary equipment, will be located in the basement, turbines will be of the single runner, vertical, plate steel spiral case type, with curved concrete draft tubes and they will be direct connected to 6250-kv-a., 300-r.p.m. vertical generators with direct connected exciters.

While the Delaware development is being made, or shortly thereafter, it is planned to complete the full projected development of the Mongaup River by the diversion of the Toronto Reservoir storage into Swinging Bridge Reservoir as previously mentioned. The difference in elevation between the two reservoirs when both are full is 150 ft.

It is planned to build a pipe line between these two reservoirs, leading to a power plant on the westerly edge of Swinging Bridge Reservoir at a point about 2.5 mi. upstream from the Swinging Bridge dam, thus making it possible to utilize the Toronto Reservoir storage, first under the head between these two reservoirs, and secondly under the head of the Swinging Bridge plant.

The power plant will house a single-runner, vertical, spiral case turbine, having a capacity of 1350 hp. at 140 ft. head and 900 hp. at 90-ft. head, direct connected to a 1125-kv-a. vertical generator, 3-phase, 60-cycle, 2400-v., at 600 r.p.m. with direct connected exciter.

It is planned to run the unit continuously at a fixed gate opening without attendance. The governor will be adjusted to operate against a load-limit device fixed to suit the head on the plant at any time and changed periodically as the head varies. It is estimated that a monthly adjustment will be all that is necessary. In case of loss of load due to line trouble, the governor will close the wheel gates and shut the unit down until an operator visits the plant and again synchronizes the unit with the system. Under average conditions, it is estimated that this plant will operate from July 1 to January 1 and be closed down the other six months in each year.

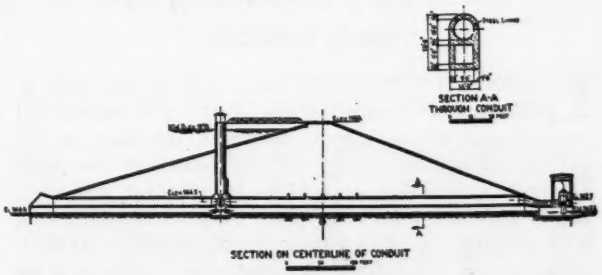


FIG. 6. SECTION OF SWINGING BRIDGE DEVELOPMENT

Personnel

The entire work is being carried out under the supervision of F. C. Sargent, vice-president in charge of engineering for Charles H. Tenney & Co. He also conducted all negotiations connected with the purchase or condemnation of lands and flowage rights, the closing or relocation of highways and bridges, relocation of telephone and oil pipe lines, cemeteries, and so on. R. S. Greig of Charles H. Tenney & Co. has been in charge of the preliminary field work, consisting of surveys, borings, test pits.

Designs and specifications were prepared by Chas. T. Main, Inc., under the writer's direction, in coöperation with the engineering staff of Charles H. Tenney & Co.

Mason T. Whiting, L. G. Ropes and E. M. Wilbur have acted as resident engineers on various parts of the work.

Construction work has been carried out by Fred T. Ley & Co., Inc., under Angelo Morris as superintendent.

Electric equipment for the Mongaup Falls plant is of General Electric Co. make. The Rio plant equipment was provided by the Westinghouse Electric and Manufacturing Co. The generator and transformer for the Swinging Bridge plant will be provided by the Allis-Chalmers Manufacturing Co. and the switchboard and switching equipment by the Westinghouse Electric and Manufacturing Co. The hydraulic equipment for all three plants is of S. Morgan Smith Co. make.

The wood stave pipes for the Mongaup Falls and

Rio developments were furnished and erected by the Continental Pipe Manufacturing Co.

The penstock, steel bends and flexible cradles for the Rio development were furnished and erected by the Walsh Holyoke Steam Boiler Works.

The Rio differential surge tank and the Swinging Bridge penstock were furnished and erected by the Petroleum Iron Works Co.

The pumping units, both pumps and motors, for hydraulic sluicing, are of Allis-Chalmers Manufacturing Co. make. The 20-in. high carbon manganese steel sluicing pipe was supplied by the American Rolling Mill Co.

The spiral riveted pressure pipe and hydraulic giants were supplied by Abendroth & Root Manufacturing Co.

Some Reasons for the High Cost of Producing Ice

By C. T. Baker

IN MANY ICE PLANTS, the power or fuel cost of producing ice is entirely out of line with economical practice and while, in some instances, this may be due entirely to conditions beyond the control of the management, it is also true that in many other instances, the trouble lies within the plant itself as the following will indicate. A plant having a daily capacity of 60 t. of ice a day had, from the beginning, suffered from excessive power cost. Current was supplied at a cost of 1½c per kw-hr., a part of which was used at 2200 v. and a part at 220 v. from a bank of transformers located just outside the compressor room wall.

During capacity operation, the current cost per ton of ice was $1.05, which represents a current consumption of 70 kw-hr. per ton, a very high figure, especially for the type of plant in question.

A check-up on the voltage at the terminals of the 220-v. motors disclosed some rather interesting facts.

One 10-hp. and one 7½-hp. motor-driven centrifugal pump supplied the condensing water for the plant under normal conditions. A voltage reading made at the terminals of these motors showed that, in place of 220 v., only 198 v. were being realized. This represented a drop of 22 v. between the transformer secondaries and pumps. In the case of another 5-hp. motor which was directly connected to a low-pressure air blower, the voltage at the motor terminals was 200 while at the terminals of others of the 220-v. motors, the voltage noted was 206 and 210 respectively. Since the voltage at the transformer secondaries with all motors in service, was found to be correct, it was evident that something else was wrong.

A check on the size wire used for the several induction motor circuits disclosed a very deplorable condition. In no case was the cross-sectional area of the circuits sufficient to insure full voltage being delivered to the motor terminals with the motors running at anywhere near capacity and, in the case of the circuit supplying the two circulating pumps, the size wire used was hardly sufficient for the smaller unit. The net result of this, a condition created by an irresponsible electrical contractor, was overheated motors, loss in motor efficiency and abnormal current consumption.

Since the investigation described was made during the hot season, it was not possible to close down the plant until the following winter, consequently it was necessary to continue for several months to pay a premium on ignorance.

Condensing Pressures

It was observed that the condensing pressure was higher than should obtain where the amount and temperature of condensing water available was such as found in this plant. An examination of the atmospheric condensers in service disclosed that the pipe of each stand had been painted with heavy black paint, the base of which apparently was tar. This material made an excellent nonconductor of heat and, since the system was found free from air, the high condensing pressure noted was due very largely to paint.

To make matters worse, the metal strips which had been provided to improve water distribution over the coils, had been removed during the painting operation and not replaced, with the result that much of the water delivered to the condensers was not effective because of wastage. Two liquid receivers had been installed but improperly connected and improperly located with reference to each other, consequently it was difficult to maintain a liquid seal at all times. This condition likewise operated to defeat efficient operation.

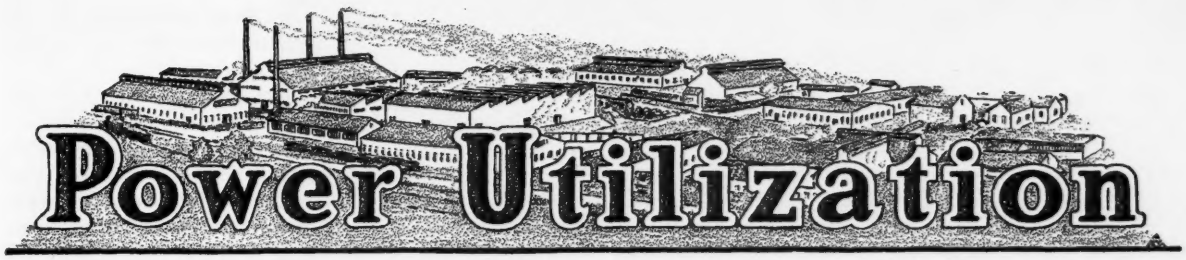
In another plant, a steam-driven distilled water ice plant, an enclosed type feedwater heater had been installed for heating the feedwater with exhaust steam before delivery to the boilers.

As the heater selected was not equipped with an oil separator for removing oil from the exhaust steam, a separator had been purchased for this purpose but was placed between the heater and atmospheric steam condensers with the result that much of the oil had been deposited on the shell and tubes of the heater, thus reducing its capacity for heating water, since the oil proved an exceedingly good nonconductor of heat.

For circulating water over the ammonia condensers, a compound steam-driven duplex fire pump had been installed at the time the plant was first built and had been in service several years. This pump was not only far too large for the plant requirements but also was not suitable for the low head service required by the existing pumping conditions which could have been much more efficiently met by the use of a general service pump.

It is always difficult to reconcile conditions as found in the two cases discussed, with modern engineering practice, nevertheless such conditions do exist in far too many plants and are obviously taking a heavy toll in operating expense.

Electricity can be produced most economically by large generating units and it can be transmitted and distributed with the greatest advantage if all the electrical needs of a large community or a number of communities are supplied in one common system. The modern tendency is for the small individual community generating plant of earlier years to disappear and be replaced by the distribution system of a larger company, either a public utility or a combination of industrial plants.



Conservation of Wire Rope*

LUBRICATION, PROPER INSTALLATION, PROTECTION FROM CHAFING AND CARE IN OPERATION PROLONG LIFE. BY J. R. MCCAUSLAND**

AS A USER of wire rope, the Coal Bureau of the Philadelphia Electric Co. system has kept careful and accurate records over a period of 10 yr. on wire ropes used in the service of hoisting and hauling equipment for the handling of coal and ashes. Conclusions reached are, however, applicable to nearly all kinds of wire rope installations. These are that the life of wire rope can be increased appreciably by proper care and lubrication and by the selection and maintenance of sheaves, drums and other apparatus suitable for the rope. There is, however, a widely varying and inconsistent span of rope life, when used by the same individual in the same service and under the same conditions, which would indicate a variation in materials or fabrication of rope as supplied by manufacturers.

FACTORS OF CABLE LIFE

Factors in life of wire rope are materials, manufacture, installation, operation, maintenance, inspection and last, if not most important, the human element in the use and care of rope. Uniformity of quality of material entering into the manufacture of the cable is the primary requirement. Next in importance are the physical properties of strength, resilience and hardness necessary for a particular service.

In the fabrication of wire rope, uniformity is also a basic necessity. Other factors of equal importance that have a bearing on the life of the rope are type of construction, shape of cable and factor of safety used.

Equipment features which may increase or decrease the life of a given cable, include sheave diameter, weight and inertia for a given rope size, load and speed; groove profile and surface material; journal friction governed by type of bearing employed; number and type of return bends; relative positions of drums and sheaves; fleet of sheaves; type of grips on cable ways.

Operation factors affecting cable life are height of lift, load per trip, number of stops, number of cycles, running speed, acceleration and deceleration, smoothness of operation and nature of atmosphere surrounding the equipment.

Maintenance involves care in the lubrication of cables, dressing of worn or scored grooves, alinement of sheaves, splicing of cables and the making of end connections.

Inspection determines when the life of a cable shall be considered terminated.

THE HUMAN ELEMENT

In our estimation, the greatest single factor affecting the life of wire rope is the human element, or the attitude of men toward its care and use. With so many factors involved, it is easy for those directly responsible on the job to find reasons for rope failures and, in probably nine times out of ten the operator will blame the quality of rope rather than investigate for other possible causes. Consequently, one of the first prejudices of operators to be broken down is that cables are manufactured haphazardly, resulting in inherent weakness. It has been our policy to send operators on an inspection trip through the manufacturing plant of a reputable wire rope concern. In every instance, the men return with the conviction that much thought, care and expense are employed to turn out the product which they handle.

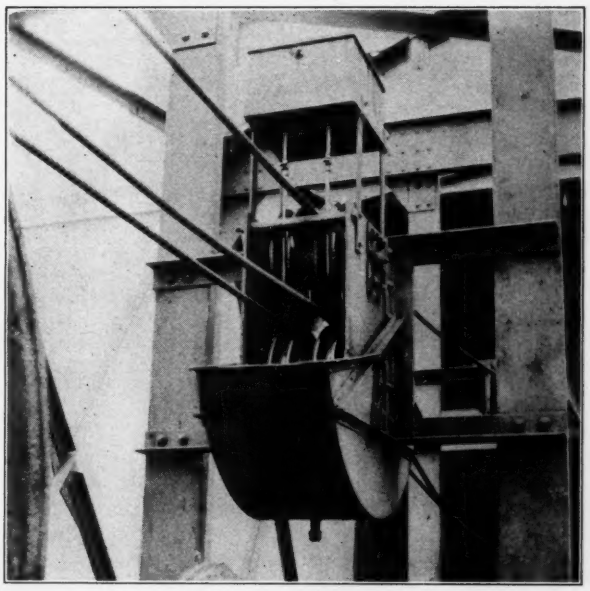


FIG. 1. CONTINUOUS ROPE OILING DEVICE

Coöperation with rope manufacturers is essential to the attainment of maximum rope economy for any given service. In the absence of accurate methods of dynamic

*From a report to the A. S. M. E. on Wire Rope Research.
**Superintendent Coal Bureau and Steam Heating Section, Philadelphia Electric Co.

testing of wire rope, the purchaser is dependent upon the rope manufacturer for guidance in the selection of the proper rope for his particular purpose. The manufacturer has definite experience from other similar applications upon which he can base his recommendations as to rope material, lay and construction features best suited to the job. He can also give advice as to changes in equipment design, methods of attaching load to rope, splicing, operation and equipment maintenance, which are helpful in prolonging rope life. In some instances, the gains from methods he recommended may not warrant the expenditure involved.

Rope Sense

Although wire rope appears to be a sturdy piece of fabrication, it is subject to all the exigencies attendant upon moving machinery, such as wear, complex stresses and corrosion. Hence care of rope is little more than the exercise of common sense precautions, or the use of what one manufacturer calls "rope sense." Failure in most cases can be anticipated by visual inspection after the rope has seen service.

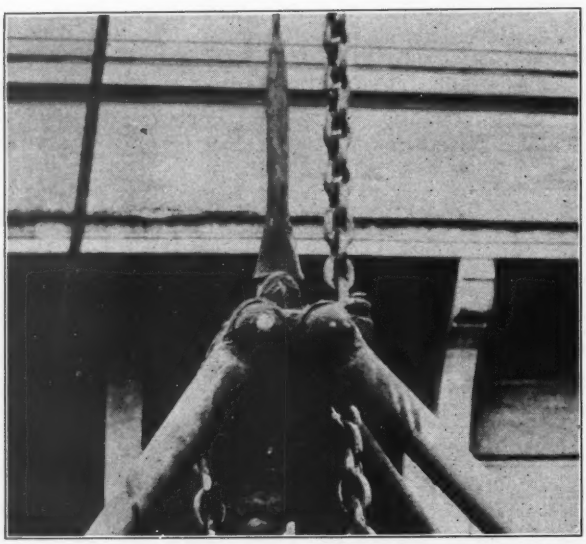


FIG. 2. EYE-SPLICE BOOT FOR CLAM SHELL BUCKET HOLDING LINE

In our use, abrasion is the most important factor contributing to rope failure and always precedes the breaking of wires due to stress. Corrosion plays no part in our failures. Thus, any means employed to reduce friction increases rope life.

Lubrication

Under all circumstances, lubrication is a reducer of friction. Where the parts to be lubricated are easily accessible and inspected, reasonable care by the operators can be expected. But rope lubrication by means of a paint brush is inconvenient and tedious. Moreover, when compound, grease or heavy oil is used, which has an affinity for coal or other dust in the surrounding atmosphere, inspection is difficult, disagreeable and uncertain. Even if proper attention is paid to lubrication by the operators, the crust formed by the mixture of grease and dust defeats the purpose of lubrication by preventing the penetration of fresh lubricants and by acting as an abrading medium when the rope passes around sheaves and drums.

To assure the proper lubrication of wire rope, on our coal towers and cableway a continuous lubricating device, which was developed by one of our operators, has been installed, as shown in Fig. 1. It feeds continuously to the ropes while operating a common, black, acid-free oil which penetrates to the core without forming a crust upon the rope. Grease and compound, however, do find application in work under water to resist corrosion of rope.

Abrasion

Misalinement of sheaves results in rubbing of rope against sheaves.

Flat surfaced drums permit adjacent rope coils to scrub each other in winding and unwinding operations, which is prevented by grooving the drum, so as to space rope coils apart.

Restricted fleet or movement of sheave adjacent to a drum produces an angle of lead between sheave and drum which causes the rope to rub against the sheave and the drum groove or against adjacent rope coils on the drum. Our policy is to use single-layer, grooved winding drums with the adjacent sheave arranged to fleet the entire width of the drum, thus reducing abrasive wear and cable crushing effect to a minimum.

Groove profiles which pinch the rope aggravate abrasion. All of our sheave and drum grooves are U-shaped having a diameter at the bottom of the U about $\frac{1}{16}$ in. greater than the nominal size of rope.

Ordinary metal surfaces of sheave grooves, idlers and grips on cable roads will wear or score rapidly, with the result that severe abrasive action occurs on the rope. Our chilled cast-iron idlers on cable roads were replaced with idlers of cast steel. These also wore rapidly. Finally the steel idler groove surfaces were filled in with hard steel by welding, filed to the required diameter and heat treated, by which method longer life is obtained on both the rope and the idlers. Filling worn surfaces by welding was also tried on cable grips but a better method was found. When the top and bottom pieces of the grips were made of tool steel, surfaces in contact with the rope became polished in service, thereby minimizing wear on both rope and grip. The life of a tool steel grip is about five years, thereby reducing the cost of grips by about 75 per cent.

Scrubbing action between rope and stationary iron guides may be eliminated by replacing stationary guides with sheaves. Where sheaves cannot be used, the iron guides may be covered with hardwood wearing pieces.

Of necessity, clam shell buckets have small diameter sheaves. These, together with the twisting action of rope at the load end and the severe abrasion of the cable in passing through guides and coal, cause buckling and failure at the bucket and more rapidly than elsewhere in the rope. To compensate for the more numerous failures at the bucket, ropes were purchased long enough to permit the bucket ends to be cut off several times. When, after successive cuttings, the rope becomes too short, it is replaced with a new rope. In the case of Chester Station where difficulty was experienced with lead between drum and adjacent sheave, the additional length of rope is coiled inside the drum. Clamped on

the drum is only the required length so that the fleet angle is maintained at a minimum. As the bucket end is cut off, additional rope is let out of the drum and reclamped.

It was found that approximately one-half the length of the holding and closing ropes from the bucket end suffered greater wear than the other half. At first the good half of a removed rope was used on cranes requiring shorter lengths. Later it was decided to wear the rope down completely by reversing it end for end and so distributing wear evenly over the entire length. It is estimated that this method of reclaiming rope is equivalent to about 15 to 20 per cent of the rope life.

Splices

At the bucket, the eye-splice of the holding line is subjected to abrasion from the whipping action of the closing line. A splice boot designed by one of our operators and shown in Fig. 2 has served well in preserving splices, thereby contributing to rope conservation.

Splicing has an important bearing on rope life. Unless properly done, a raised strand will develop in service, with a consequent misapportionment of both wear and stress, which leads to early failure. Our operators are trained to pull the strands of a splice to an equal tension and to keep the splice perfectly round in order not to distort strands in other parts of the rope. The ends of strands on eye splices are tucked in even and true. Rope on our cable roads are spliced endless on the machine. A 40-ft. long splice or better is used, strands being carefully laid in and 30 in. of the ends tucked into the center of the rope, replacing the core. The ends are taped before tucking in. A 30-in. tuck is found to resist cable grips better than the usual 18-in. tuck. To guard against strands slipping out of place, it is essential that the strand tucked in shall completely fill the void left by the removed core.

Stresses from Bending and Jerking

Rope stresses, in our service, break the outside wires of strands after abrasion has reduced their cross-section 30 to 40 per cent. When 50 to 60 per cent of the outside wires are broken in a 5-ft. length, the rope fails.

Bending, tensile and shearing stresses are augmented respectively by: Small sheave and drum diameters and reverse bends; rapid acceleration and deceleration of load; improper reeving of rope. The degree in which these stresses are imposed upon ropes determines whether stress or abrasion is the paramount cause of short rope life.

Originally, installation at the Chester Station was that known as the Watson Rig on hoisting. It destroyed rope almost as fast as put on. The Watson Rig, a counterbalanced hoist, had a large number of small diameter sheaves and reverse bends. Due to the extraordinary number of rope failures, this rig was replaced shortly after installation by the present hammerhead tower, similar to that shown in Fig. 3, which is the Richmond Station. A grab bucket is raised or lowered by a double drum hoist as in diagram, Fig. 4A, through leads operated over a trolley running on a horizontal boom which projects out over the boat to be unloaded, a separate drum controlling the movement of the trolley. Figures 4B and 4C are the arrangements for Richmond and Delaware stations, progressively, simpler. One man operates the entire outfit. The Delaware equipment practically relegates bending stresses to secondary consideration.

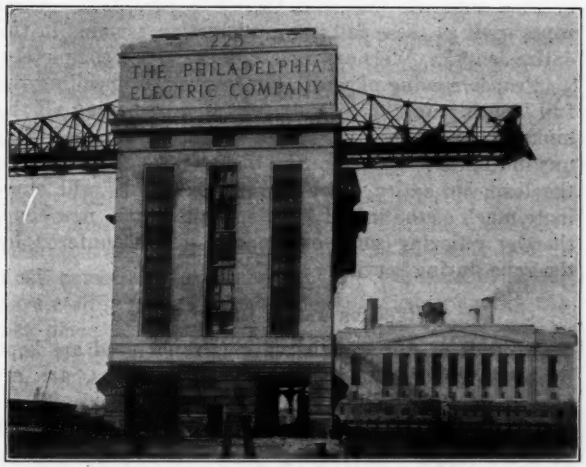


FIG. 3. HAMMERHEAD COAL TOWER AT RICHMOND STATION

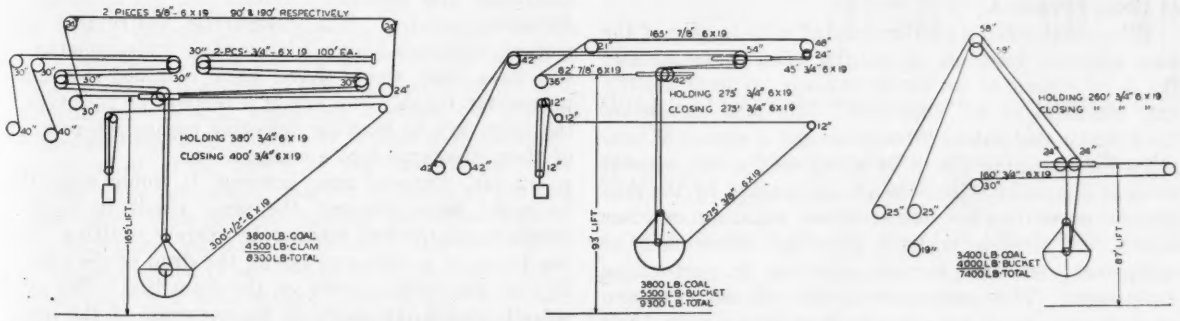


FIG. 4. A. CABLE AND SHEAVE ARRANGEMENT. B. SIMPLER ARRANGEMENT AT RICHMOND STATION. C. LATEST ARRANGEMENT FOR STEEPLE TOWERS

Acceleration stresses, however, must still be reckoned with, especially after abrasion has weakened the ropes. Failure of rope due to acceleration stress is usually traceable to the operator. On a bucket hoist, employing holding and closing lines, operation must be such that both lines carry their proportionate share of the load. An operator can cause a closing line to fail earlier than

a holding line by hoisting with the closing line alone. On the other hand, the operator can cause the holding line to fail earlier than necessary by jerking the empty bucket to a sudden stop at the bottom of its travel. Operators have thoroughly impressed upon them the fact that rapid start or stop of a load, jerking and uneven cycles are as detrimental to cable life as wear and abrasion, especially after the ropes become worn. The result is that operators exercise increased caution with increased age of the rope. No operator desires to be charged with the failure of a rope regardless of its age. To a considerable extent, this spirit among the men is responsible for the fact that we have four ropes at one of our stations which have handled from 250,000 to 366,000 t. each and are still working, whereas the original rope life was from 60,000 to 100,000 t. When ropes such as these fail, no good section remains in the entire length. We now wear out the ropes completely.

Proper reeving of wire rope consists in uncoiling the full length required, in a straight line, removing all the kinks, winding the full length on the drum and then unwinding the rope from the drum, through sheaves to the load, its entire length. This procedure will eliminate much of the initial twist encountered in new rope, thereby relieving some of the stresses encountered by the rope during service.

Records and Competition

Records of duty on the various ropes used are kept by our yardmasters in the separate stations, are reviewed monthly and at yardmasters' meetings. Competition is fostered among the men on rope life as well as other apparatus coming under their supervision. Problems are discussed at the meetings where combined thought is put to work on the individual needs of each station. Constructive suggestions are encouraged and at times rewarded.

Plans and policies are formulated with the aid of the men affected, resulting in cordial labor relations and the development of an esprit-de-corps, at once healthy and beneficial to all concerned. The men themselves have formulated rules of discipline and a system of penalties for operating errors by which they abide, without trace of dissension. Records are maintained by the men themselves on time lost due to illness, accidents or other causes, on careless mishaps affecting either men or equipment; on time savings achieved in performing daily tasks. They take pride in the efficient condition of their equipment, the cleanliness of their plants, their personal appearance.

In the constant search for improvement, manufacturers' representatives are cordially received by our men, who are ready to coöperate along any lines of action holding promise of increasing the combination of efficiency, economy and safety.

Summary

Many types and makes of ropes were used before it was found that the standard 6 by 19 plow steel rope with hemp center gave the equivalent life of any, due in part to faulty construction of plant, reverse bends, and small sheaves of equivalent, as shown in Fig. 4. It is to be noted that the sheaves are 24 and 30 in. diameter, whereas they should be at least 54 in. Improvements have been made, however, up to the point where further investment is unwarranted even though the rope life might be considerably increased.

Hauling Cables

On the cable road we installed light and easily removable straight idler rollers for the straight of way, made of pieces of pipe fitted with aluminum ends, to replace cast-iron idlers. These rollers were designed by one of our operators and have cut our expense of maintaining the idlers to about one-quarter. As soon as the pipe part of the roller is worn out, another piece of pipe is cut off and clamped between the aluminum ends.

Speed of rope was reduced and type of counterweight changed to permit a closer adjustment of rope tension.

On the curve idlers, the profile and material was changed using steel instead of cast iron. Worn surfaces have been restored by welding and heat treating, thus saving the castings and consequently effecting considerable saving in maintenance.

In summarizing the whole situation, the greatest single factor entering into the increased life of wire rope is the care and operation to which rope is subjected. Too often ropes are placed on apparatus for which they are not designed, or upon equipment designed without regard to rope life; or, on the other hand, placed on apparatus and entirely forgotten as to care and lubrication, with little thought given to the condition of the apparatus itself. So, while it is possible for the manufacturers to improve the fabrication of wire rope, it is equally possible for the users of wire rope to effect greater savings simply by applying "rope sense."

Defective Pumps

In the April 1 issue, C. W. Stevens described an admirable and economic method for determining the defective pumps. The measuring instrument and method, although rough, give a close approximation of the data that would have been obtained by using piezometer tubes. The use of a method of this type is the only way in locating defective pumps where many of them discharge into a common line.

In Mr. Stevens' case, however, it would seem that he could have obtained the same result in a much cheaper and quicker manner by merely shutting down one pump at a time and noting the drop or decrease in flow on his venturi meter on the main line. The exact output, within the limits of the accuracy of the meter, could thus be obtained for each pump.

The rough pitot tubes that Mr. Stevens used will, however, give a reliable check on the relative output of the different pumps and the idea should be commended to all who have no permanent meter installation.

Canton, N. C. Harold Hansen.

In gear pumps, the theoretical discharge is obtained by calculating the double volume of liquid expelled by the teeth of one wheel from the spaces between the teeth of the other wheel. The clearance between the ends of the teeth on one wheel and the roots of the teeth on the other wheel must not be neglected.

By creating excessive leaving losses, an exceedingly high vacuum may actually lower the turbine efficiency.

Efficiency and Long Life for Storage Batteries

PROPER METHODS OF CHARGING, DISCHARGING AND CLEANING ARE THE REQUISITES FOR SECURING BEST SERVICE FROM BATTERIES. BY CHARLES A. PETERSON

DURING the past few years, storage batteries have come into such common use, that a general outline as to the proper care to increase their efficiency and lengthen their useful life will be of value.

Edison alkali type batteries are extremely rugged and are not readily damaged even by allowing them to stand in a discharged condition. Beyond keeping the electrolyte at the proper level in such batteries, no special care is required, hence no further consideration will be given them.

APPLICATIONS OF BATTERIES

By far the greatest number of batteries in use at the present time, are those found on automobiles and

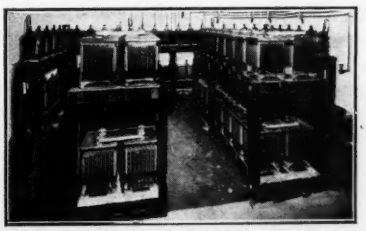


FIG. 1. STANDBY EXIDE BATTERY FOR LIGHTING LOAD OF BUILDING. 25 CELLS IN BACKGROUND SERVE TELEPHONE SYSTEM

trucks, although thousands are in use on radio receiving sets. Other common applications are for telephone work, signal operation, car lighting, operating switchboard auxiliaries in power plants, operating self-propelling trucks, as a source of standby energy in isolated power plants. Several years ago, a street car system was operated south of Chicago by means of storage batteries installed in the bodies of the cars, the batteries being exchange for freshly charged batteries at the end of each trip. This system required no poles, feeders, trolley wires or bonded rails. Recently one of the eastern railroads placed in service, the first number of locomotives which will have three sources of power, storage batteries, Diesel engine and trolley or third rail current. The storage batteries will allow operation beyond the trolley wires or third rail for switching cars into industrial plants where trolley wires or third rails would not be permitted for safety reasons.

CONSTRUCTION AND WORKING OF A BATTERY

When a storage battery is called upon to furnish energy to a circuit or the energy is being restored by charging, certain chemical changes take place in the electrolyte as well as in both sets of plates. The change which takes place when the battery is being charged is the reverse of that taking place when the battery is furnishing energy.

First of all, it may be well to look over the elements of a battery. The simple battery is composed of a container, a negative plate and a positive plate separated by a thin wooden insulator, and the electrolyte. A number of cells connected together constitutes a battery. Larger cells may contain a large number of positive and of negative plates. The larger the number of plates in a cell, the greater the current capacity and the greater the number of cells in series the higher the voltage of the battery, as the voltage of a fully charged cell is approximately 2.2 v.

Examination of a fully charged battery will show the positive plates to be of a dark brown or chocolate color, while the negative plates have a dull lead color. A chemical analysis would show that the active material in the positive plate is mainly lead peroxide (PbO_2) and the negative plate mainly metallic lead (Pb) in a spongy condition. The electrolyte is a mixture of water (H_2O) and sulphuric acid (H_2SO_4). The electrolyte penetrates the pores of both plates and the more readily it can permeate every portion of the active material, the more readily the chemical action producing energy can take place.

While furnishing energy or discharging, the SO_4 from the electrolyte combines with the elements of both

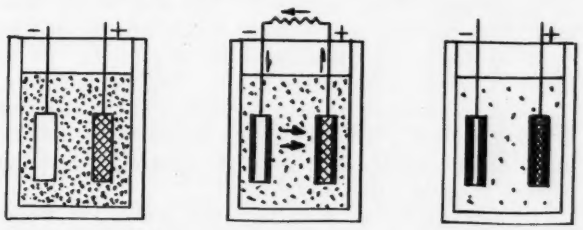


FIG. 2. CELL FULLY CHARGED. POSITIVE PLATE, ALL LEAD PEROXIDE. NEGATIVE PLATE, ALL SPONGE LEAD. VOLTAGE AND ELECTROLYTE DENSITY MAXIMUM

FIG. 3. PARTLY DISCHARGED CELL. EACH PLATE PARTLY LEAD SULPHATE. VOLTAGE AND ELECTROLYTE DENSITY DECREASED

FIG. 4. FULLY DISCHARGED. PLATES LARGELY LEAD SULPHATE. VOLTAGE AND DENSITY AT MINIMUM

plates, forming lead sulphate ($PbSO_4$), the remainder of the solution towards the end of the discharge period being mainly water although some acid is always left in the electrolyte.

As the discharge progresses, the specific gravity of the electrolyte gradually becomes less and the voltage also gradually decreases. Eventually, a point is reached when both plates contain considerable lead sulphate and current ceases to flow. In practice, discharge is not allowed to go to this point but is discontinued when the voltage has dropped to a certain figure, depending upon the particular type of battery and the service demanded. Usually the voltage should not be allowed to drop below 1.75 volts per cell.

Batteries should not be allowed to stand in a discharged condition for any great length of time, because

lead sulphate occupies a greater amount of space than the original lead peroxide and, as the active material has expanded considerably in changing from lead peroxide to lead sulphate, any further discharge beyond the normal tends to crowd out the active material in the plates, closing the pores and rendering it difficult to recharge the battery. For this reason, the manufacturers usually specify a certain specific gravity of the solution, below which the battery should not be discharged. Promptness in placing a discharged battery on charge greatly prolongs the useful life of the battery.

FIG. 5. 60 CELLS, 480 AMP. FOR INSTRUMENTS AND EMERGENCY LIGHTS

In charging a battery, we reverse the procedure which took place in discharging. Direct current of the correct amperage is forced through the battery in the opposite direction from that obtaining when the battery was discharging. The chemical action which took place in discharging is also reversed. The acid which combined with the lead in the plates is now driven out and again combines with the water in the electrolyte. Eventually the plates are restored to their original condition, the positive reverting to lead peroxide and the negative to metallic lead. The electrolyte increases in density until, finally, all the acid is in the electrolyte and the battery is again fully charged.

In this condition, a battery can stand for weeks without deteriorating and cannot readily freeze, due to the density of the electrolyte being high. In a discharged condition, a battery will readily freeze as the electrolyte is mainly water.

Temperature Rise Governs Charging Current

Batteries should be charged at the correct current value, the current required depending upon the battery in question. Electric current, in flowing through a battery, produces a certain amount of heat, just as it does flowing through any other circuit. The temperature of the battery should not be allowed to exceed 110 deg. F. as a high temperature will disintegrate the plates and separators. The temperature rise of the battery governs the current rate allowable in charging a battery.

Towards the end of the charging period, bubbles of gas will be observed rising at both sets of plates. The gas rising at the positive plates is oxygen and that at the negative plate is hydrogen. These gases are the result of the charging current breaking up a portion of the water in the electrolyte into its elements, hydrogen and oxygen. It is customary to reduce the charging current when gas begins.

In considering the capacity of a battery, the rate of discharge must be considered. Any storage battery can deliver its normal current in a certain number of hours but will not deliver twice that current in half the number of hours, nor can it deliver four times its normal current in one-fourth the normal time.

For instance, a certain battery will deliver a total of 112 ampere-hours in 72 hours but will deliver only 80 ampere-hours in 8 hours and 60 ampere-hours in 3 hours. So the maximum output from a battery is obtained when a small amount of current is drawn from the battery over a long period of time rather than a heavy current drawn over a shorter period of time. The reason for this is that when normal discharge takes place, the chemical action can penetrate to all portions of the active material, while the heavier current drain tends to complete the chemical action only at the surface, closing up the pores of the active material so that the acid does not reach the inner portions. When the surface of the plates becomes covered by a hard skin of sulphate, the battery is capable of delivering a portion of the unused energy contained in the interior of the plates, by reducing the rate of discharge or by allowing the battery to stand idle for a short time.

It is customary to give batteries an equalizing charge occasionally, usually called an overcharge, by continuing the charging beyond the normal period of time and

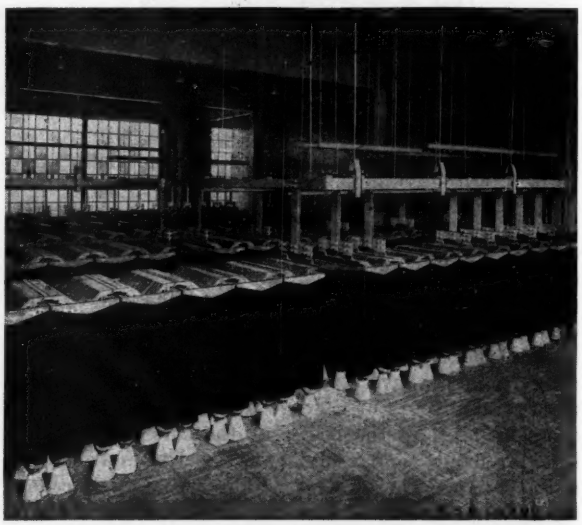


FIG. 6. STANDBY BATTERY FOR EMERGENCY CITY LIGHTING

at a somewhat lower rate. When overcharging, gas is freely emitted and, as it is explosive, care should be observed in the vicinity of the battery to avoid open fires, flames, sparks and cigars.

Add Only Distilled Water

To compensate for water lost by gas as well as that lost by evaporation, water must be added at intervals to keep the level of the electrolyte at the correct height. Great care must be exercised in the selection of water for this purpose as contaminated water will quickly ruin a battery. Only approved water should be used. Distilled water is available nearly everywhere and is safe to use. Rain water, if it is not contaminated by contact with metallic salts or foreign objectionable matter, is also suitable. Rain water may become contaminated by

contact with gutters, down spouts or containers made of metal, so it should be kept in glass or earthenware vessels.

Electrolyte Density Is Test of Condition

Density of the electrolyte is the only positive check upon the amount of energy in the battery. The open-circuit voltage reading means but little, as a battery when nearly discharged may show practically full voltage, especially if it is allowed to stand idle for several hours. The density of the electrolyte, however, gives a true and accurate check upon the amount of energy still left in the battery.

It is well always to take the hydrometer reading at the same cell, called the pilot cell, as the density of the electrolyte may vary considerably in different cells. After taking 50 or 60 readings from the pilot, change over to another cell, making this one the pilot cell for several months. The pilot cell should be marked. The reason for changing over from time to time is that at each test some of the electrolyte may remain in the hydrometer and, in the course of time, the electrolyte becomes diluted so that inaccurate readings are obtained.

Tops of the cells gradually accumulate dust and dirt which may eventually cause a serious leakage of current, flowing from the positive pole to the negative by way of the dust, especially if it becomes moist. Corrosion of the terminals is also sure to follow, if the tops of the cells are not kept clean. In fact, all parts of the battery should be kept clean by wiping off any dirt and moisture that accumulate.

Batteries that are regularly removed from industrial tractors for charging purposes are often difficult to handle. The changing and moving of such batteries should therefore be made as convenient as possible, to eliminate heavy lifting and possible damage to the batteries by rough handling, not to mention possible injury to the workmen. A four-wheeled truck of the proper height should be provided.

When a comparatively small number of batteries are in service, the Tungar type of charger is often used and is quite satisfactory. For larger installations, motor-driven generators are usually installed. The Tungar charger rectifies alternating current to a pulsating direct current suitable for charging purposes. The full-wave rectifier should always be selected in preference to the half-wave type as the former is more economical to operate.

Avoid Dopes and Nostrums

Various dopes or special patented preparations, are often advertised to renew batteries but they should be strictly avoided. The government has investigated a number of such preparations and the result of their findings is contained in Technical Bulletin No. 94 published by the Bureau of Standards, Department of Commerce, Washington, D. C.

To sum up, the various points to observe in caring for storage batteries will be listed.

1. Follow all instructions prepared by the manufacturer.
2. Never allow batteries to stand in a discharge condition for any length of time.
3. Keep electrolyte at the correct level by adding approved water when needed.
4. Avoid exceedingly heavy current drains upon the battery.
5. Unscrew vent caps on the cells when charging.
6. Keep the tops of cells clean.
7. Give batteries a 25 per cent overcharge 5 or 6 times a year.
8. Use a reliable hydrometer to determine the condition of the battery and use it regularly.
9. Do not drop batteries nor tip them far enough to spill electrolyte.
10. Be sure the battery room is kept clean and have it ventilated.
11. Avoid open fires, flames, sparks and lighted cigars in the vicinity of batteries on charge.
12. Keep a record of the hydrometer readings obtained, so that any unusual variations will call attention to an abnormal condition which may be remedied before it becomes serious.
13. Never allow the battery temperature to exceed 110 deg. F. nor allow a discharged battery to stand at a freezing temperature.
14. In case extensive repairs are necessary, it pays to secure a skilled lead burner to handle the work.
15. Never add raw acid to a battery.

One who has had no experience in caring for storage batteries need have no fear of assuming such responsibility, if he uses a little common sense and is able to secure the advice of an experienced man to start him out right. By mastering the fundamental principles relating to batteries and following a few simple rules, he is well on his way to becoming a good battery man. Anyone engaged in electrical work will have no difficulty in acquiring the necessary knowledge in a short time.

In conclusion, in mixing electrolyte, never pour water into the acid as this is extremely dangerous. The proper procedure is to use a large glass or earthenware jar, pouring approximately the required amount of water into the jar and gradually adding the acid. About four parts of water are required to one part of acid. The mixing will generate a certain amount of heat. After it has cooled, it can be diluted to exactly the required density. Concentrated acid usually has a specific gravity of 1.830, water being 1.000. The specific gravity of electrolyte is usually between 1.230 and 1.345 when prepared for a new battery with charged plates. The manufacturer's recommendation should be strictly followed.

Provide for Easy Checking of Instruments

Periodically one reads of the tremendous value of instruments showing the pressures, temperatures, etc., of all types of operations, particularly in power plants. All magazines have an article on this subject at intervals. Recommendations are made for periodic checking, careful calibration, frequent inspection, etc.

While instrument men are as a rule conscientious about the accuracy of their instruments, often, especially in the smaller industrial plants, no arrangements have been made for the easy checking of the instruments, so that this operation is quite laborious and often neglected because of the difficulties encountered.

For example, I have personally endeavored to check thermometers, particularly the recording type. Often the only method of doing this is to remove the bulb from

the well and insert a glass checking thermometer into the well in the line. After long intervals, I have found these bulbs so firmly held in the wells by incrustations or swelling that to attempt to remove the bulbs meant twisting them off or damaging them to the extent that they were ruined. I have even found a few bulbs screwed into lines without any wells whatsoever, so that removal was impossible without shutting down the equipment. This necessitated checking in a bucket of hot water at other than operating conditions.

It has been my experience that the most advantageous method of testing thermometers is to add a small ½-in. well to the pipe line adjacent to the regular thermometer well, so that the latter can remain in place and in operation while the checking thermometer need only be inserted in the small test well. In this way, an accurate and simultaneous test can be made. These small test wells can be purchased with a screw cap, sealing them from dirt, etc. They should be filled with high grade mineral oil which is always at temperature, minimizing the time required to bring the test thermometer to temperature.

The same is true of pressure gages. Most boilers are regularly equipped with a test outlet in the regular pressure gage line on top of the boiler close to the boiler outlet. Steam line instruments are less often so equipped. I have seen men check recording pressure gages by placing a test gage on the gage line at the instrument, even though the instrument is located on a board at the floor level while the gage line is connected to the boiler outlet at the top of the boilers many feet above the instrument. No consideration is given for the water leg, so that the final reading may be 10 lb. high. The plant should provide a test connection for each pressure instrument located within a few feet of the point of connection of the gage line with the boiler or pipe line whose pressure the instrument is to show. This may mean that two men may be required to check indicating pressure gages, such as boiler steam gages, one to watch the test gage on the boiler or line proper while the other reads the instrument to be checked, for the readings must be simultaneously made.

The same thoughts can be applied to other types of instruments, such as CO_2 recorders, flow-meters, etc., where connections can be made to facilitate greatly the checking of permanent instruments.

Dayton, O. C. W. Stevens.

Repiping Kinks

Repair and rearrangement of the piping system in a factory was agreed upon by the management after a full inspection and consultation regarding the old system. The plant had been idle for some time, so that overhauling was needed anyway and, as the engineer said, "the piping wandered around too much." It was put up to the engineer, therefore, to wreck the system and repipe it from boiler to dry room, salvaging as much as possible of the old material.

Fittings cost less than pipe, so every possible length of pipe and every good pipe thread were to be saved. The men were to tap each fitting lightly but thoroughly. pulling on the pipe with pipe tongs only hard enough to start the joint, without cutting, splitting or flattening the pipe. If the joint could not be started without injuring the pipe, cast-iron fittings were to be broken off, without injuring the pipe and, for malleable fittings the pipe was to be cut off as close to the fitting as possible, the end to be kept in shape for rethreading.

Only a few pipes had been cut off when the engineer found that the cutting off tool was closing the pipe some 20 to 25 per cent. As no reamer was available, cutting with a hack saw was ordered but carelessness of the workmen resulted in cuts that were not square.

Instructions were then given to slip a fitting over the pipe, when possible, as a guide for the hack saw blade; if this could not be done, to wrap a piece of stiff paper around the pipe, bringing the ends even and tie it on with a string, to give a guide for a square cut.

Soon the engineer found a workman cutting ends square and quickly, using neither fitting nor paper guide. Watching, he found that the man put on a cutting tool with a dull cutter, gave it one turn around the pipe with light pressure to groove a ring square with the pipe, then cut to this groove with the saw.

When rethreading, the die was run on until it was exactly flush with the end of the pipe. This gave a thread that would screw into a fitting exactly six turns, so that the amount to be allowed in making up joints would be always the same. If, by chance, a die was run on too far, or an old thread was too long, the end of the pipe was cut off, to be flush with the face of the die. Any short pipe thread, old or new, was rechased so that the die face was flush to the pipe end.

Like attention was given to details when reërecting the system. All horizontal runs were to be pitched away from the boiler, so that moisture would drain with the steam, and drip pockets installed where water would tend to collect.

All screwed pipe joints that might have to come down occasionally, as around injectors and boiler appliances, were made up with a mixture of fine graphite and lubricating oil. Other joints which would seldom or never be disturbed were made with red lead, white lead or litharge mixed with linseed oil. Joints buried under ground were made with litharge and glycerine. Wherever a fitting was found, which was tapped too large and could not well be thrown away, the joint was made with No. 1 Smooth-On. The engineer said that those and the ones made with litharge and glycerine would never be broken except with a sledge or hack saw.

In the matter of applying "dope" on the joints, the engineer was "fussy." No daubing it inside the fittings! It must be applied evenly and not too thick to the pipe threads. "Dope daubed into a fitting carelessly gets in lumps at the end of the pipe, hardens and may stop up half the area of a small pipe," was the explanation.

"Put it on the male thread, just enough to fill the threads, and any surplus is forced back to the outside end of the fitting. You can wipe it off there and, anyway, it will do good rather than harm. And you won't have dope balls breaking off and sticking up valves."

With such attention to details, naturally the layout and pipe runs were carefully planned and, needless to say, the new system served its purposes well and gave no trouble.

Indianapolis, Ind. James F. Hobart.

High Efficiency Obtained from Wood Waste Fuel

EDITOR'S NOTE: In the original manuscript of an article under the above title written by K. P. Mykkanen and published on page 334 of the March 15, 1930 issue, appeared three items of an unusual nature. The first was the "effective calorific value" of wood waste calculated by formula, the second the use of 430 deg. C. (806 deg. F.) steam for industrial plant service and the third was the term "normal steam" used in Europe for the same purpose as "evaporation from and at 212 deg. F." is used in this country. Normal steam in addition to the latent heat includes the heat of the liquid from 0 to 100 deg. C. Mr. Mykkanen's detailed reply to a letter requesting a full explanation of these terms follows:

By "effective calorific value" of the fuel is meant a figure expressed by the following formula based on the latest Swedish investigations:

$$W = 4590 - 51.9\ F \text{ kgcal. per kg.}$$

(an older one says $W = 4400 - 50\ F$)

W meaning the effective calorific value and F moisture expressed as a per cent of the weight. This formula, however, can be used only if the fuel concerned is wood. In English units this would be

$$W^1 = 8270 - 93.5\ F$$

W^1 meaning the B.t.u. per pound.

In Europe and probably in America too, efforts are made to superheat the steam to a high degree. The temperature of 430 deg. C. (806 deg. F.) will in the near future be considered as normal. In our older plants the highest temperature allowed is 375 deg. C. (697 deg. F.), the temperature of 430 deg. C. mentioned being quite temporary and owing to the overload. The boilers and steam turbine of our new sulphate mill at Enso are, however, constructed for 425 deg. C. (797 deg. F.) and in practice the temperature nearly always remains at this figure.

Piping and valves of this mill are made of steel, the valves having been delivered by Hopkinson in England. Owing to our short experience, the (mill was started three months ago) we, however, cannot yet form any judgment as to durability of them; hitherto they have stood the test.

Here in Europe the usual standard of comparison for evaporation results is the "normal steam", containing 639 kgcal/kg. (1150 B.t.u. per lb.) which means such steam contains liquid heat from 0 to 100 deg. C. (32 to 212 deg. F.) plus evaporation or latent heat of 539 kgcal/kg. (970 B.t.u. per lb.) the pressure being 1 absolute atmosphere.

Enso, Suomi-Finland. K. Mykkanen.

Stoker Ram Repair

IN THE PRACTICE of engineering, it has been my good or bad fortune, whichever way you wish to look at it, to be employed in plants of 300 boiler horsepower or smaller, the greater portion of the time, where it was

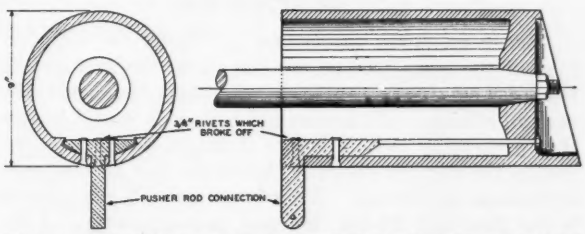


FIG. 1. SECTION OF 9-IN. RAM WHOSE PUSHER ROD ARM CAME ADRIFT

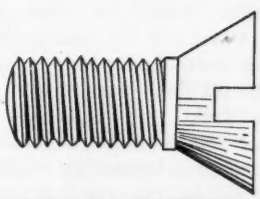


FIG. 2. SCREWS WERE SUBSTITUTED FOR RIVETS TO HOLD THE ARM TO THE RAM

and is hard to get or keep repair parts on hand and sometimes you are forced to do repair jobs in ways which would never be attempted or thought of in larger plants, where they usually have at least a few essential spare parts.

Figure 1 represents the ram of a 9-in. underfeed stoker. The three rivets holding the pusher rod arm in place, either broke off or pulled out one evening just before quitting time. No other ram, complete, was obtainable and the stoker had to be in service by 6 p. m. the following day.

This ram case is in two parts, top and bottom. The cap screws holding these to the retort were taken out and cylinder and ram case moved 2 in. away from the boiler. The ram case was unbolted from the cylinder, bolts holding the top and bottom halves were taken out

and the arm was released from the pusher rod connection. Then we could turn the ram over with the pusher rod arm up.

We tried to get the nut off the end of the piston rod but could not move it, so got the old rivets out of the holes in the pusher connection. Fortunately we had a lathe and a few tools so the holes in the pusher rod arm were drilled and tapped $\frac{1}{2}\frac{5}{8}$ in. The holes in the ram were countersunk and three large screws made like Fig. 2 with a generous slot in the head ½ in. wide. Screws were put in and plenty of elbow grease applied to tighten them.

This job lasted 3 yr. after repairing, until replaced by a new ram and ram case. This particular stoker had been bought second hand and installed in a hurry, so the pusher rod arm may have been loose when put in. The nut was stripped off the rod running out through the front of the ram but there was stock enough left to thread with ½-in. die and length enough to put on two nuts.

Every ram is now inspected before installation and, if there are any loose rivets or nuts, which have been found twice in new rams, they are repaired before the ram is put into service.

Minneapolis, Minn. FRED S. RUTLEDGE.

Ventilation and Preheated Combustion Air

EVERY ENGINEER knows that the higher the temperature of the gases passing up the stack, the greater the loss of heat in the furnace gases and the lower the over-all efficiency of furnace and boiler. It is well known that preheating the air before it enters the furnace increases the furnace efficiency, hence the over-all efficiency of furnace and boiler. What is not so well appreciated is the fact that 10-deg. increase in temperature of incoming air is worth more than a 10-deg. reduction in stack temperature. Were this fact more generally realized, greater effort would be taken during the cold weather to use warm air for combustion purposes, instead of leaving doors and windows open so that air, often as low as 30 deg., rushes into the ashpit and through the fuel bed.

Preheated air was heralded a number of years ago as a promising factor in improving combustion efficiency. It was soon found, however, that the use of preheated air might radically increase the difficulties due to formation of clinker and molten ash, as well as causing refractory troubles especially where the degree of preheat was considerable while the ash fusion temperature was relatively low. This, however, is an extreme case. In general, a 10-deg. F. increase in incoming air represents a real saving in fuel due to higher combustion temperature.

Proper application of engineering principles regards a small saving as better than no saving, when the cost of establishing that saving is warranted. This is demonstrated in a recent instance when an engineer developed a rather ingenious method of using preheated air, while at the same time solving an objectionable condition over which, otherwise, he would have had no control.

Headroom and ground space being valuable in a typical downtown hotel plant, the boiler room was located in the sub-basement in extremely cramped quarters where there was little headroom and where the boilers were overloaded severely during the cold weather. In order to take care of the increase in load, mechanical stokers had been installed during the summer months, increasing boiler capacity about three times over hand-firing. During the cold weather, however, it was found that the room above, which consisted largely of kitchen and similar quarters, became seriously overheated, so much so in fact that the quarters were almost untenable. Covering the boilers more thoroughly seemed to have no effect upon the temperature of the rooms above the boiler room. Eventually it was decided to ventilate the ceiling of the boiler room and in this way reduce the heat passing through the floor to the room above.

Disposal of the hot air in the upper part of the boiler room could be made most easily, obviously, by passing it up the stack. Since every degree increase in incoming air temperature represented an increase in furnace temperature, it was decided to collect the hot air along the ceiling of the boiler room, drawing it by chimney draft into the ashpit, hence through the fuel bed. In this way, the problem of ventilation would be solved, giving also great promise of improving the over-all combustion efficiency. The ashpits to the chain grates were closed up with sheet iron and a sheet-iron duct was carried up from each ashpit to a common header supported from the ceiling of the boiler room. This header was spread out so as readily to collect the air for the fires from the ceiling.

Comfortable temperature was maintained in this way in the room above the boiler room while the air for combustion was preheated to an extent which has resulted in a noticeable saving in fuel. This instance shows that it frequently is possible to accomplish two things at the same time and shows how an engineer who understands the fundamental principles of engineering is able to turn a dilemma into an advantage.

Chicago, Ill. C. G. CROWLEY.

Fuel Oil Storage Tank Ventilation

REFERRING to the statement, on page 398 of the April 1 issue, which says that oil storage tanks should never be cleaned without airing the tank for at least two days before a man is allowed to enter, we have reduced this required time to one hour, by the use of compressed air.

Prompt repair of the heating coil in one of our fuel oil storage tanks, which had frozen and burst, was urgent because a car of oil was expected to arrive at any moment and it was desired to repair the coil before refilling the tank. After flushing out the tank with water to remove the settlings, a ½-in. air line was run from the plant's air supply, an air hose attached to the drain valve making the connection to the tank.

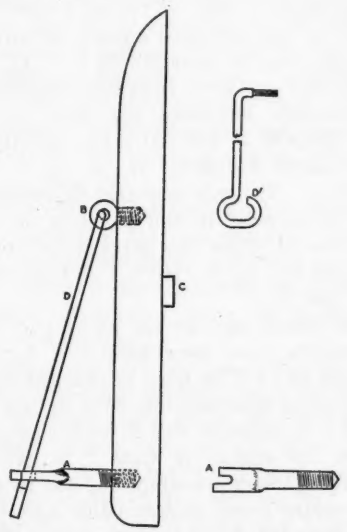
Air, which had passed through a reducing valve, was admitted to the tank at 45 lb. pressure. After an hour's operation, the tank was entered and the coil repaired. There was little trace of gas when we entered the tank and none of the men felt any bad effects after working an hour in it. The air was left blowing while the men were at work in the tank. This method requires a large amount of air but for quick results it cannot be beat.

Walthill, Nebr. WM. W. DINGWALL.

Cool Fire Door Handle

USE OF SWINGING door handles is not a new idea but the design illustrated is new. I once saw a similar handle, having a lug cast with a hole in it on the door at B which meant that a special door had to be used. In this case also, the handle support at A was straight, permitting the handle to slip off and lie against the door where it would become as hot as the door itself. The new construction of A is shown at A^1 and that of the handle at D.

After the threaded end of the handle is entered through the hole in the eyebolt, B, a nut is screwed on its end. A slight upward pull on the handle will lift the door off the latch at C and the door will open freely.



ATTACHMENTS TO FIRE DOOR PERMIT OPENING IT BY HAND

The eyebolt, B, and the support, A, are threaded to screw into holes in the door. This handle will usually be cool enough for quick handling without burning the hand.

Ordinary doors are opened by the fireman generally by use of the shovel. This often injures the edge of the shovel. If desired, the loop on the handle can be wound with asbestos rope to make it more comfortable to handle.

Toronto, Canada. JAMES E. NOBLE.

Keep Flame Away from the Girth Seams

LEAKS DEVELOPED in a stoker-fired return tubular boiler, the girth seam of which was located just even with the rear of the bridge wall so that the flame impinged strongly on the rivet heads. The second time it happened, I was called on for an opinion and, upon investigation, found the top of the bridge wall within 16 in. of the boiler. Cutting two rows of brick off the top of the bridge wall stopped the trouble. The boiler can carry a bigger load and more easily than formerly.

Minneapolis, Minn. FRED S. RUTLEDGE.

IN GENERAL, the smaller the turbine the lower the efficiency.

Sodium Aluminate Boiler Water Treatment

MOST WATER treating engineers will concede that it is more desirable to remove scale forming salts from water before it enters the boiler than it is to treat these same salts inside the boiler. The supposition upon which the article on "Tri-Sodium Phosphate Controlling Boiler Concentrations," by H. R. Williams, published on page 467 of the April 15 issue, is based is that with cold process lime and soda softening, the probable hardness left in the water after treatment will be something over 2 gr. per gal. Undoubtedly a hardness of this degree would cause trouble in the boiler unless after-treatment were resorted to.

Would it not be much more efficient and desirable to produce from the water softener a much better grade of water than that described above? A water with one grain or less of hardness in it would surely give better results in the boilers than a water of 2.5 gr. hardness with after-treatment.

Many up-to-date plants treating with lime and soda ash are also using sodium aluminate in conjunction with them. The addition of this chemical produces at a very slightly increased cost, water far superior in quality to that which can be produced without it. Average tests for the week April 14 to 19 inclusive, made at plants in which this treatment was used in various kinds of softeners and on various types of water are shown in the accompanying list.

Plant Located in	Hardness of Treated Water
Shelbyville, Indiana	1.5
Rockford, Illinois	1.1
Claflin, Kansas	0.8
Middletown, Ohio	1.0
Hastings, West Virginia	0.9
Ottawa, Illinois	0.5
Akron, Ohio	0.7
Cincinnati, Ohio	0.7
Canonsburg, Pennsylvania	0.7
Hoult, West Virginia	0.8
Mishawaka, Indiana	0.8
Carton, West Virginia	0.9

None of the above plants is using any after-treatment in the boilers to prevent scale formation. The pressures vary from 150 lb. to more than 400 lb. In some instances, sodium sulphate is being used as an after-treatment to build up the sulphate total alkalinity ratio to insure against embrittlement.

In view of the above data, is it not more feasible and desirable to produce from the softener, a water which will not need any corrective after-treatment to prevent scale than it is to produce a relatively poor water from the softener and then correct the fault inside the boilers?

Chicago, Ill. H. A. GUSTIN.

THE TEMPERATURE at which air becomes saturated and the moisture begins to condense out is called the dew point. In power plants, it is not good practice to cool flue gases to this point, because the moisture which condenses out is from the sulphur in the coal and is highly corrosive.

Questions and Answers

Unusual Savings by Change in Installation

IN LOOKING over the article with the above title, published on page 250 of the February 15 issue, it would appear that a saving of 21.4 per cent in the coal bill due to the installation of a return trap is to say the least "unusual." While there is in this case a direct saving due to the use of the return trap, there are probably other savings which, indirectly, are due to the changes made.

In order to arrive at some conclusion as to how the various savings should be allocated, it would be well to start with the assumption that the coal consumption, both before and after the change, is directly proportional to the output of the boiler and, from the available data, construct a heat balance. The initial layout, as shown in the original article, will be referred to as Case 1, and the modified arrangement as Case 2.

In Case 2, the combined steam consumption of the engine and feed-pump is given as 2700 lb. per hr. and, of this amount, 2500 lb. is charged to the engine and 200 lb. to the pump. In Case 1, the steam consumption of the pump is taken as 350 lb. per hr., this figure being in accordance with the results obtained from various tests of direct-acting pumps.

DATA AVAILABLE FOR COMPUTING HEAT BALANCE

	Case 1	Case 2
Steam pressure, lb. per sq. in.	110	110
Total heat of steam, H, B.t.u.	1190.2(H)	1190.2(H)
Temperature of high pressure returns, deg. F.	210	320
Heat of liquid high pressure returns, B.t.u.	178 (h_1)	288 (h_2)
Temperature of feedwater, deg. F.	210	190
Heat of liquid feedwater, deg. F.	178 (h_1)	158 (h_3)
Back pressure	?	0
Water handled by pump, lb.	6750	2700
Pounds of steam per hr. to process	4050	4050
Pounds of steam per hr. to engine	?	2500
Pounds of steam per hr. to pump	350	200

In Case 2, the total amount of heat supplied per hour by the boiler, will be: $Q_2 = 4050\ (H—h_2) + 2700\ (H—h_3) = 4050 \times 902.2 + 2700 \times 1032.2 = 6{,}440{,}850$ B.t.u. Then the total amount of heat supplied by the boiler in Case 1 will be in the ratio of 28 to 22, the ratio of coal used: $Q_1 = Q_2 \times (28 \div 22) = 8{,}200{,}000$ and the decreased amount of heat generated by the boiler will be: $Q_3 = Q_1 — Q_2 = 8{,}200{,}000 — 6{,}440{,}850 = 1{,}759{,}150$ B.t.u. Consequently, the savings due to the use of the high-pressure returns at the higher temperature available can be represented by: $Q_4 = 4050 \times (h_2—h_1) = 4050 \times 110 = 445{,}500$ B.t.u. The savings due to the decreased amount of steam used by the feed pump can be represented by: $Q_5 = (350 — 200) \times (H—h_1) = 150 \times 1012.2 = 151{,}830$ B.t.u. Then the total savings accounted for are: $Q_4 + Q_5 = 445{,}500 + 151{,}830 = 597{,}330$ B.t.u. and the total savings unaccounted for are: $Q_8 = Q_3 — 597{,}330 = 1{,}161{,}820$ B.t.u. The only way that Q_6 can be accounted for is by an increase in the quantity of water evaporated in Case 1. Then this extra weight of water will be represented by: $Q_6 \div (H—h_1) = 1{,}161{,}820 \div 1012.2 = 1150$ lb. per hr.

Since the steam used by the pump and by the high-pressure process have been accounted for, this additional amount of 1150 lb. must be charged to the engine, making the steam consumption, 3650 lb. per hr. in Case 1; although it is apparent that there is considerable back pressure on the engine in Case 1, a saving of 31.5 per cent in the steam consumption, due to the decrease in back pressure seems unreasonable and part of this must be accounted for by improved combustion conditions, by decreased load or by other conditions not mentioned.

According to the original assumption, the final heat balance is then:

	B.t.u.	Savings Per cent	Fuel saved Per cent
Savings due to return trap.	445,500	25.4	5.5
pump	151,830	8.6	1.8
engine	1,161,820	66.0	14.1
Total	1,759,150	100.0	21.4

Since two-thirds of the above savings are credited to the engine, it would be well to test the engine with various back pressures to find out whether the findings, as shown above, actually have any relation to the actual conditions.

Chicago, Ill. JULIUS BRODSKY.

Reversing Shaft Governors

IN REGARD to the answer to J. O. L. published on page 355 of the March 15 issue about reversing shaft governed engines, I can see where a man unacquainted with these governors might get mixed up, if he took as literal truth the answer as given. It is usually unnecessary to turn the flywheel end for end and it is, indeed, sometimes an impossibility to do so. Some governor wheels could not be turned around because

this would bring certain lugs, stops or cast raised faces on the wrong side of the wheel and perhaps make it impossible to hook up the valve gear at all. Imagine what would happen in the case of some of the overhanging pin types.

Another point is that the flywheel does not necessarily carry the governor at all, as in the Fitchburg engine, in which there is a separate small governor wheel. In any event, when discussing governors is it not better to speak of the governor wheel? For it is that, even if it be also the flywheel.

There is a great difference in the work necessary to reverse some of these engines as compared with others. This may vary from a case in which all that must be done is to dismantle the governor and reassemble it in the new position, everything being interchangeable and all holes and lugs being provided, to an extreme case in which it would be necessary to provide an entire new wheel and possibly some other parts. Often the wheels are provided with the strengthening lugs cast on them for both directions of running but they may not have the holes drilled. In this case, these holes must be drilled true and square.

Possibly the engine may need a new eccentric sheave because, on account of the slot being too short on one end, it may be impossible to make the eccentric lead the crank in the new direction with the right angle of advance and, in other cases, it may be necessary to cut new keyways for the wheel.

In presenting the idea that, in whichever direction the engine may run, the governor must move the eccentric center in toward the center of the shaft as the weights themselves move outward and that the eccentric must lead the crank at exactly the same angle for the new position as it did in the old, we find the fundamental requirements and, if these are followed, there should be no trouble, although much work may be involved in reversing any shaft governor.

Turners Falls, Mass. W. W. WHITE.

Care of Water Pump Plungers

CAN YOU GIVE me any information on the care of water plungers on pumps?

2. Should grease be used on them or not?

3. Have you any data on the power required on greased plungers as compared with ungreased plungers?

J. R. H.

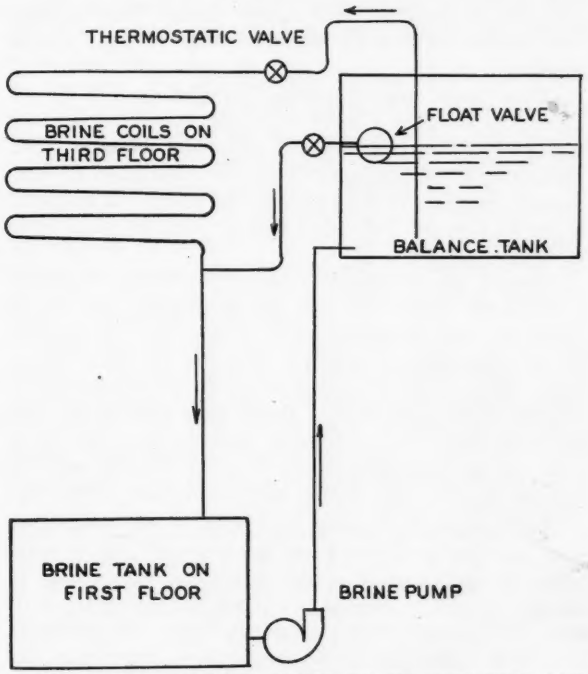
A. In general, the best care that can be given plungers on outside-packed plunger type pumps is to see that the plungers are kept in line with the cylinders, central in the stuffing-boxes and the stuffing-boxes well packed with some good grade of plunger packing suitable for the conditions of service on which the pump is operated. This packing should be of a type having some lubricating qualities either in the nature of oil or grease impregnation or graphite. The plungers should be carefully calipered from time to time to insure that they are round and straight. There is a tendency for plungers to wear tapered, which will result in wear of packing, leakage and, occasionally, in the breakage of cylinders.

As to greasing plungers, authorities differ. For ordinary conditions of service in handling cold water, we believe that no lubricant, outside of that in a well selected stuffing-box packing, is necessary.

We know of no data on power used by friction of plungers. With proper stuffing-box packing and with proper pressure on the glands, we doubt whether it would be possible to find any difference in power required on the greased, as compared to the ungreased plungers. The packing in the stuffing-boxes on outside-packed plunger pumps should not be pressed too tightly. A slight seepage is desirable rather than objectionable.

Brine Circulation Cooling System

How CAN a centrifugal brine-circulating pump be connected with a brine cooling coil which is situated two floors above the brine tank and pump so as to permit of constant operation of the pump, although the circulation through the brine cooling coil is cut off from time to time by a thermostatic valve? E. O. S.



FLOAT VALVE PERMITS BRINE TO BE BYPASSED AND PERMITS CONSTANT OPERATION OF PUMP

A. In order to have the circulating pump continue to operate after circulation through the cooling coils has been cut off by a thermostatic valve, it is necessary to provide a bypass which will be opened when the thermostatic valve is closed.

If the cooling coils are to be placed two floors above the circulating pump, it will be necessary to provide a balance tank at the same level as the cooling coils, as shown in the illustration. The pump will then feed this tank and the brine will circulate through the coil as soon as there is sufficient head on the intake which is submerged in the tank.

If the thermostatic valve is closed, the liquid level in the balance tank will rise until the brine operates a float valve, when it will be discharged through an overflow to the pipe which drains the cooling coils to the brine tank. The pressure due to the difference in levels of the discharge through the overflow and the intake, must be greater than that necessary to force the brine through the cooling coils.

Editorial Comment

How Good Is Good Enough?

Strange as it may seem, this question is often extremely important to the power plant engineer, particularly in the industrial plant. It always arises when a job of any sort is to be done that is more or less temporary in character.

To say that the work should be done as well as possible is insufficient for, in each individual case, the terms "as well as possible" and "good enough" are relative, determined entirely by the conditions of that special problem.

This point was effectively brought out by A. C. Barker in the May 1 issue of Power Plant Engineering and we feel that it deserves considerable emphasis. Mr. Barker referred particularly to the installation of temporary electric power circuits in the plant but the principles he brought out apply equally well to other types of work.

One of the principal factors influencing temporary work is the possibility that the temporary job will be found to work so satisfactorily that it will be operated as a permanent installation, contrary to the original plan. What engineer has not had the experience of installing temporary wiring, steam lines and water lines for some new type of process machine that was being tried out as an experiment, only to find that the machine worked so well that it was kept in regular operation?

Such experiences soon lead him to the conclusion that it is better to carry out a temporary job in shipshape manner, even at a little extra cost rather than to double the cost by having to rip out the temporary stuff and install permanent equipment later. So, although the term "good enough" is relative, experience has proved that temporary work should be of a much higher quality than some people might think necessary. It often involves just as much analysis of future conditions, just as much planning for efficiency, just as much care for safety as many permanent installations.

That item of safety is all important on a hurry-up temporary job. Underwriters rules or local ordinances may cover much of the work but, as Mr. Barker points out, liberal quantities of common sense are needed, too. Every engineer shrinks from the thought that men may be injured because he failed to take all possible precautions. Besides, awkward and costly delays in production may be caused by ignorance on the part of process machine operators. The latter, who seldom have much knowledge of power, must be fully protected.

Thus the question "How good is good enough?" is not always so easy to answer. If we do the temporary job with the best materials in the best possible way, the cost may be all out of proportion to the efficiency—Lord Kelvin's law again. On the other hand, if we try to "throw it together," stringing a few wires around with a few knife switches and open fuses, some old hose to carry steam or water and a general attitude that any old thing will do, we are sure to get into trouble, either through injury to workmen or interruption of service. Somewhere between these two extremes lies the answer. To obtain a satisfactory solution in a given case is one of the best tests of an engineer's ability to plan and construct.

Better Buildings and Grounds

Among the reasons why directors of some institutions and even manufacturing establishments have decided against building and operating their own power plants is the fear of difficulty and expense in harmonizing the building for the plant with the beauty of the surroundings. The coal and ash piles, which are thought by many to be a necessary adjunct of a power plant, are unsightly and intolerable at many institutions. That those objections can be overcome is being demonstrated in many plants throughout the country. Not only do the power plants harmonize with their surroundings but in some instances they combine utility with beauty in such a way as to make the plant an attractive feature of the institution.

Without doubt the initial cost of a building with attractive architectural features will be somewhat greater than for one which is a mere covering for the machinery housed therein but any institution, such as a college or hospital, whose patronage depends to some degree upon the appearance of the surroundings will find the additional expense justified not only by increased revenue but also by more economical operation because of the higher class of employes such surroundings are able to attract.

Architecturally the power plant building can be made to harmonize with almost any scheme of construction; even the stack to which some object can, by using induced draft, be brought down to a height that is not objectionable, although some prefer to design it into an attractive shaft. With modern methods, coal and ash conveying and storage can readily be carried on entirely within the building. Distribution cables and piping for all services are being installed in tunnels and do not enter into the architectural treatment of the building.

Landscaping surrounding the power plant may be made just as attractive as that around any other building provided fuel is delivered in trucks; railroad tracks sometimes complicate this problem. Spray ponds and cooling towers are essential at some plants and attractive designs have been worked out, one of which may be noted at the Bureau of Standards plant which is described in this issue. The play of colored lights on a spray pond is a feature of some plants.

Putting the power plant department on a par and in harmony with other departments of an institution or factory is a problem of which all phases need careful consideration and the aesthetic side deserves greater consideration than is commonly given it.

Off Duty

In his fascinating book, "The Nature of the Physical World," Professor Eddington supposes a discussion between the Astronomer Royal, and Professor Bergson on the nature of time. As a philosopher, Professor Bergson's authority on the subject is well known. The Astronomer Royal, on the other hand, is entrusted with the duty of finding out time for everyday use, so presumably he has some idea of what to find. To make this discussion more interesting, Eddington dates it some 20 yr. back, before Einstein's ideas brought about a better understanding of the subject from both men's points of view. There would then have been a keen disagreement and the philosopher probably would have had the best of the argument. After showing that the Astronomer Royal's idea of time was quite nonsensical, Professor Bergson would probably have ended the discussion by looking at his watch and rushing off to catch a train which was starting by the Astronomer Royal's time.

For regardless of how we may dispute the absolute significance of this thing we call time, we know that in our own lives it plays an important part and no matter how primitive our state, time consciousness is forcefully impressed on our minds. The skill of a dramatist is not required to conceive a situation in which each tick of a watch is translated into a human pulse beat. Life arranges these situations in variety so astonishing that they become accepted commonplaces.

Time, to different individuals, means different things. To shipwrecked Crusoe on a desert island, time was as vague, as valueless as the Spanish coins he uncovered in a seaman's chest. Darkness and dawn and the ebb and flow of tides were the hands that spaced the dial for him. But to an engineer of a freight train trying to run into a siding so as to give an oncoming passenger train the right of way, time is a very much more important thing. By his watch, he knows that if he can round the curve and slip into the siding with just 30 seconds to spare, he will be safe. But what if the passenger engineer's watch were 40 seconds too fast or the freight engineer's watch, 40 seconds slow? Here correct time spells human life.

The time to which these watches are referred is that which is given to us by the revolution of the earth upon its axis, that is, it is the Astronomer Royal's time. It is the time used in physics.

But those of us who have read something about the Einstein theory are probably aware that according to this theory, time and space have become mixed up in a strange way and we must no longer think of one without thinking of the other. This is difficult to understand but to explain, let us take another illustration from Eddington.

If two people meet twice we naturally assume from our experience that they must have lived the same time between the two meetings, even though one of them has traveled to a distant part of the universe and back in the interim.

A ridiculous assumption you will say—an absurdly impossible experiment, but supposing it were possible, most people would still answer, of course, that the statement is true.

We cannot send a person to another part of the universe but we have enough scientific knowledge to compute the rates of atomic processes of a body at rest and one moving at high velocity. We know that in a fast moving body the rate of atomic processes is slower than in a slowly moving body or one at rest and so in a traveler moving rapidly to a distant part of the universe and back, we can say his bodily processes are slower. This is not surprising when we consider that the mass of a body increases with its velocity. This can be observed in the case of electrons moving at high velocity in vacuum tubes. The retardation is a natural consequence of the increased mass or inertia.

Thus, in the fast moving traveler, all bodily processes will be retarded—he will live more slowly. His cycle of digestion and fatigue, the rate of muscular response to stimulus, the development of his body from youth to age, the material processes in his brain, even the watch which ticks in his pocket will all slow down in proportion.

Suppose this traveler can travel with nearly the velocity of light. While the stay-at-home individual has aged say 70 years, the traveler upon his return has aged only one year—he has lived only one year. He has found appetite for only 365 breakfasts, lunches, etc., his intellect clogged by a slow moving train has traversed the amount of thought appropriate to one year of life on earth. Judged by the time which consciousness attempts to measure, the two men have *not* lived the same time between two meetings.

The time we use, that which our clocks tell us and which the Astronomer Royal or our naval observatory at Washington gives us is the time relative to the earth. This time is not that which could be used on an interstellar plane moving at a speed of say 175,000 miles per second, nor is it the time used by an electron traveling in a vacuum here tube on earth. We say for instance that an electron travels across the space in a vacuum tube in billionth of a second, but that is only our way of measuring it. Could the electron speak, it would dispute our measure of its time of travel—the Astronomer Royal's time, it would claim was just so much nonsense, and so it is, from its point of view.

So it seems that nature has in some stronge way mixed up time and space so that we can never separate them. Yet in our minds it is difficult to think of them in any other way than as separate things. It is not a thing we need worry about, however, for if we use the Astronomer Royal's time or that given by the naval observatory at Washington, and if we keep our watches in good condition we can rest assured that for all our purposes we will have correct time. If at times we do get tangled up in an argument with a philosopher and if we cannot dispute the logic of his ideas, we can always retaliate by pointing out that it is the Astronomer Royal's time that brings the trains in on time and by which events in this world are regulated, not the philosopher's.

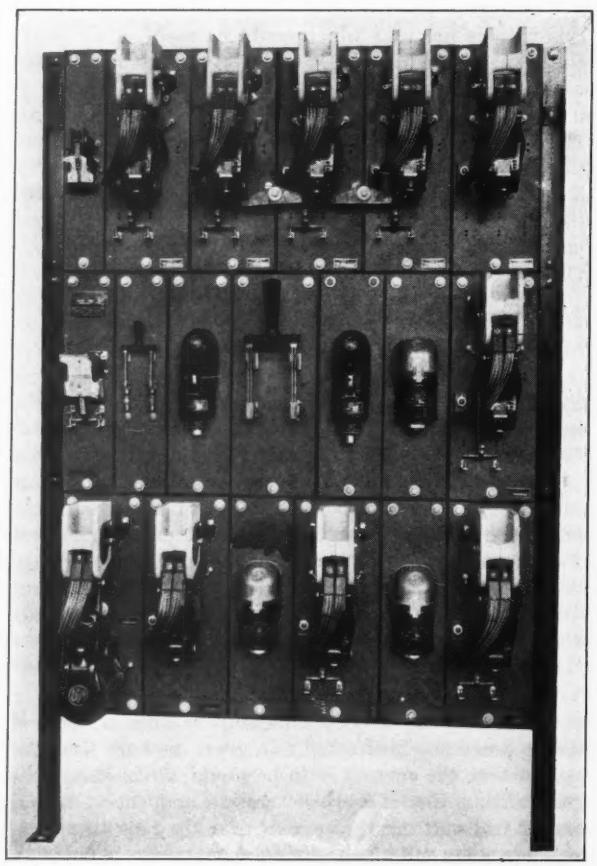
WATER POWER development may be uneconomical if the proposed site is situated at a great distance from the place where the current is to be used, as the cost of the transmission lines may be excessive and the electrical cost of transmitting the current over the long lines may be more than offset in saving over steam generating plants nearer to the point of consumption.

Power Plant Engineering Developments and News

Dynamic Braking Controller for Crane Hoists

FOR USE IN the operation of crane hoists, the Electric Controller & Mfg. Co., of Cleveland, Ohio, has developed and placed on the market a Dynamic Braking Controller, known as the "Wright Dynamic Lowering Circuit Controller." This controller is of the magnetic contactor type and is intended for use on crane, ore and coal bridge and bucket hoists.

Dynamic braking hoist controllers have hitherto been open to the objection that the release of the solenoid brake was sluggish in the lowering direction, making it necessary to pause on the first point to give the brake an opportunity to release before advancing the controller, frequent brake adjustment being necessary to prevent entire failure of the brake to release.



THE WRIGHT DYNAMIC LOWERING CIRCUIT CONTROLLER

With the new Wright Dynamic Lowering Circuit, the brake releases instantly. Instead of passing only one-third of the line current through the brake on the first point lowering, this new circuit passes all of the line current through the brake. The operator no longer has to hesitate on the first step, he can move his master controller instantly to any desired speed point. Improper brake adjustment has little effect on this quick release.

This improvement insures faster crane operation, more accurate control of short, quick movements and better ability to spot loads.

This is one of the many advantages of the new Wright Dynamic Lowering Circuit; other outstanding advantages are:

1. Faster speed when lowering light loads or empty hook.
2. Greatly reduced power consumption on all loads at all speeds.
3. Greater power return to the line when lowering overhauling loads.
4. Reduced peaks of current. The Wright Circuit takes only full load current from the line on first point lowering as compared with 150 per cent full load current on previous systems.
5. Lower heating on the motor.
6. Less contactor wear.
7. Fewer movements when inching for accurate stopping of load.
8. All of these features obtained without the use of any additional contactors.

Anderson Mill Type Grease Pump

BECAUSE the trend in present day equipment lubrication runs to heavier and more viscous materials—grease difficult to handle but effective when properly applied—the Anderson Mill type grease pump, offering a fully mechanical means for pumping heavy mill grease, has recently been developed.

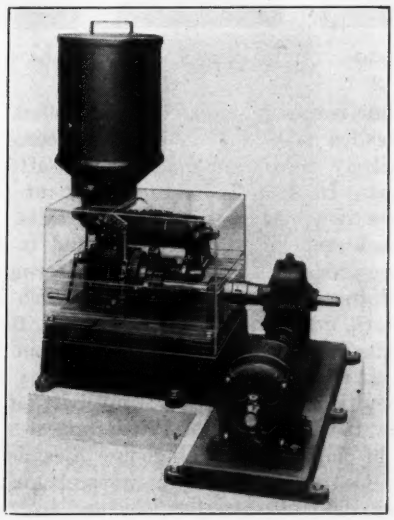
Grease is introduced into the feeding system of the Anderson mill type grease pump by means of a displacement pump operating a positive mechanical valve opened on the suction stroke and closed prior to the discharge stroke. A distributor head with the requisite number of leads is directly connected to the discharge side of the pump. The indexing of the head is secured by means of a ratchet attachment to allow indexing on the suction stroke of the pump and to remain fixed during the discharge stroke, after which it indexes to the next lead and continues in order.

Delivery lines are attached directly to the distributor head and lead to the connections of the equipment bearings. A steam heating element is installed on the bottom of the hopper casting directly above the intake valve, to facilitate handling of heavy grease during cold weather. The grease hopper has a capacity of approximately 50 lb. Other sizes are available on order.

A screen is installed in the grease hopper bottom beneath the steam heating element and above the intake valve to prevent any foreign matter from entering the pump. Provision is made for adjustment of the stroke of the pump to regulate the amount of grease delivery, also on the speed of drive through proper adjustment of the number of teeth taken per stroke, which adjusts the delivery cycle.

All running parts other than the motor and gear reduction unit are enclosed as a safety measure and to protect the mechanism from dirt or scale. The entire mechanism operates in a grease or oil bath.

The Anderson grease pump is built in sizes according to the number of feeds required. Present models consist of 4, 6, 8, 10 and 12 feeds per unit. Special sizes are made up to 24 feeds per unit. Where more than 24 feeds or leads are needed, two or more units may be connected with a common driving mechanism to secure the desired number of feeds. The pressure capacity of the Anderson pump is sufficient to deliver grease under any bearing pressure to a maximum of 5000 lb. per square inch.



PHANTOM VIEW OF NEW GREASE PUMP

This equipment is made by the Hills-McCanna Co., 2349 Nelson St., Chicago, Ill.

Gear Drives for Variety of Equipment

TWO SPEED mill drive recently designed and built by Gears & Forgings, Inc., Cleveland, Ohio, is shown in Fig. 1. One of these units is now driving a slabbing mill in one of the country's largest steel plants. On this unit, no clutch parts are located inside of the drive; the clutch is external, attached to the intermediate shaft,

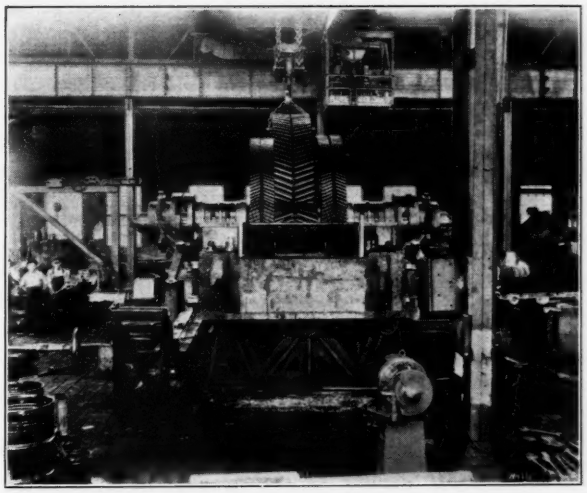


FIG. 1. TWO-SPEED MILL DRIVE FOR SLABBING MILL

to permit the use of a comparatively narrow and rigid gear drive.

The prime mover is a 1000-hp. motor for 445/590 r.p.m. The mill itself has a speed of 9.01/11.91 r.p.m. through one set of gears and 12.01/15.93 r.p.m. through the second set of gears. Overall dimensions of the drive are 26 ft. long, 17 ft. wide. The total weight is 350,000 lb.

A three-speed reducer, Fig. 2, has been recently developed by the same company for automatic stoker drives. Change of speeds is accomplished by a hand wheel operating a threaded shaft, upon which the shifting fork is mounted. This wheel, easily accessible to the operator, is to enable him to regulate the amount of coal fed to the boiler by changing the speed of the drive unit.

The change gear box consists of a splined shaft, which is an extension of the worm gear shaft mounted on two sets of Timken roller bearings, also a jackshaft upon which two sets of change gears are mounted. The sliding gears on the splined shaft engage either one of

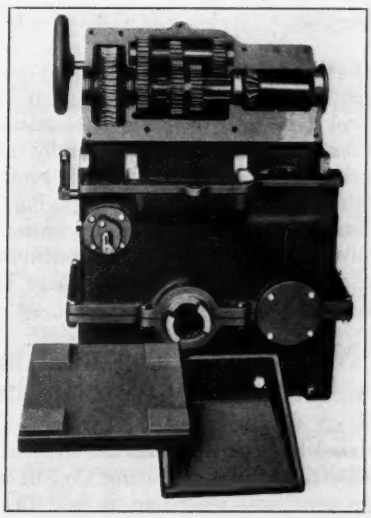


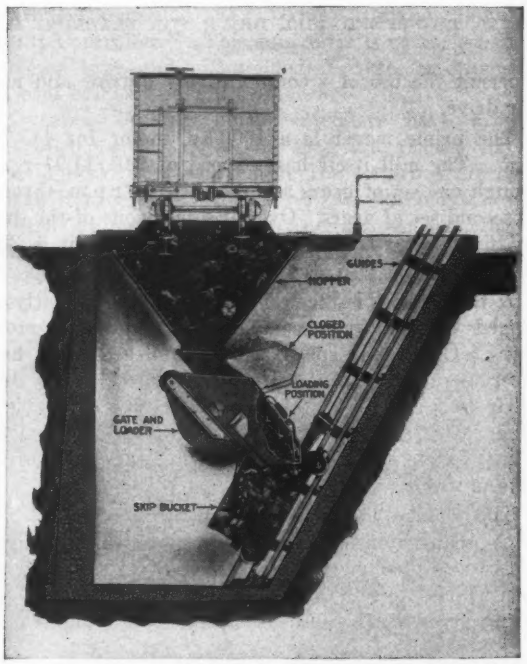
FIG. 2. THREE-SPEED DRIVE FOR STOKERS

these change gears or, by means of a clutch, engage the gear mounted on the worm gear shaft.

The housing is of high grade semi-steel, consisting of three sections split horizontally, bolted together. All change gears, bevel gears and worms are of the highest grade of carburizing steels, properly heat-treated, to give the best service for the application.

Automatic Loader for Skip Hoists

THIS NEW Full-Bucket-Control loader, made by Link-Belt Co., has a simple attachment, which consists of a swinging plate so arranged that unless material is flowing through the chute in sufficient depth to maintain electrical contact, the skip hoist will not operate. In other words, there has to be sufficient material in the hopper to fill the bucket.



LINK-BELT FULL-BUCKET-CONTROL TYPE AUTOMATIC LOADER

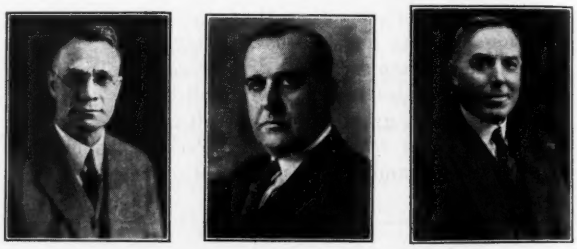
When the bucket reaches the loading position, the loader permits the material to flow from the hopper until the bucket is full, then the mechanism instantly causes the bucket to be hoisted, thereby moving the loader into its closed position, where it remains as the bucket continues to travel to the emptying point and until it returns to the loading position, where it is again automatically loaded. The bucket continues to load and empty automatically so long as there is sufficient material to fill it.

Rugg Now Heads Engineering and Sales Activities of Westinghouse

W. S. RUGG, vice-president in charge of engineering, has been placed in charge of sales activities of the Westinghouse Electric & Manufacturing Co., in addition to engineering activities, according to an announcement by F. A. Merrick, president. Mr. Rugg, by this appointment, takes over the activities of Edward D. Kilburn, vice-president and general sales manager, whose resignation was accepted by the board of directors on April 16.

S. M. Kintner, director of the Westinghouse Research Laboratory, has been made assistant vice-president, according to Mr. Merrick's announcement, and he assumes engineering department duties under Mr. Rugg's direction.

A native of Wisconsin and a graduate of Cornell University, Mr. Rugg has been associated with the Westinghouse Company since 1892. After doing engineering and sales work in the Chicago office of his company, he was transferred to New York where in 1909



W. S. RUGG E. D. KILBURN S. M. KINTNER

he was made manager of the New York office. In 1917 he was recalled to East Pittsburgh to become manager of the railway department, and shortly after, marine department. In 1920 he became assistant to H. D. Shute, then vice-president in charge of sales. In 1922 he was made general sales manager and in 1925 was elected vice-president in charge of engineering.

Mr. Kintner, well known for his research and engineering work, graduated from Purdue with the class of 1904. After graduating he spent a year in telephone construction and operation and then became a member of the faculty of the Western University of Pennsylvania, now the University of Pittsburgh.

Later he joined the Westinghouse Electric & Manufacturing Co. as engineer in research, high-tension phenomena, lightning arresters, line and apparatus protection. He became connected with the railway engineering department in charge of alternating current and railway motor design. He also investigated telephone interference, alternating-current electrolysis and was in charge of motor design for the New York, New Haven and Hartford Railway tunnel and other notable installations.

In 1911 he went with the Electrical Signalling Company, organized to develop the radio discoveries and inventions of Professor Fessenden and became, in turn, general manager, vice-president and president. In 1920 he again became associated with the Westinghouse organization with engineering and research duties.

Mr. Kilburn has resigned from the office of vice-president and general sales manager to engage in private business. He will occupy offices in the Westinghouse Building, 150 Broadway, New York.

Mr. Kilburn has long been prominent in the electrical industry. He entered the employ of the Westinghouse Co. in 1906 as a graduate student, after receiving an engineering degree from Cornell and during his long service with the Westinghouse organization, rose stead-

ily, becoming in turn manager of the New York Power and Railway Department, manager of the New York district office, vice-president and general manager of the Westinghouse Electric International Co., and sales executive of the Westinghouse Electric & Manufacturing Co.

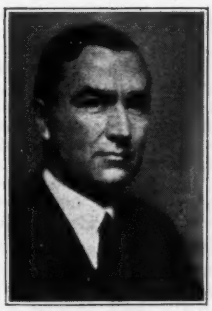
News Notes

ANNOUNCEMENT is made of the fifth Midwestern Engineering and Power Exposition to be held at the Coliseum, Chicago, Feb. 10 to 14, 1931. The entire building will be used. At the same time, meetings will be held of the Midwest Power Engineering Conference and the National Fuels Meeting of the American Society of Mechanical Engineers. These meetings and the 100,000 sq. ft. of exhibits will form a triple attraction for power plant engineers.

DAMPNEY CO. OF AMERICA, Hyde Park, Boston, Mass., announces the opening of a direct company branch office at 305 Thomas Bldg., Dallas, Texas. J. Dwight Bird will be in charge of the Southwestern Territory.

FROM MAY 1, Link-Belt Co.'s Baltimore, Md. office is located at 913 Lexington Bldg., telephone Calvert 5741. H. D. Alexander is in charge of this office, and Harry E. Reese handles the sales of Link-Belt Power Transmission Equipment.

DIRECTORS of The Jeffrey Manufacturing Co. at the annual meeting held Wednesday, April 23, at Columbus, Ohio, elected Robert W. Gillispie president and general manager of the company. He was formerly vice-president and general manager. At the same time the board elected Robert H. Jeffrey, former president of the company, to the position of chairman of the board. In electing Mr. Jeffrey to the chairmanship, the board of directors recreated a position which has been vacant for two years. In addition to being president of The Jeffrey Manufacturing Co., Mr. Gillispie is also president of two subsidiary companies known as the Jeffrey Manufacturing Co., Ltd., at Montreal, Canada, and the Galion Iron Works and Mfg. Co., at Galion, Ohio.



R. W. GILLISPIE

CONNERY & CO., INC., Philadelphia, Pa., announces the removal of its New York office to 370 Lexington Ave., on April 15, 1930.

WM. B. SCAIFE & SONS CO., Pittsburgh, Pa., announces the death of its president, James Verner Scaife, on Monday, March 31, 1930.

ANNOUNCEMENT is made that the Chicago office of the Foster Wheeler Corp. has been moved to 20 North Wacker Drive, Chicago, Ill.

FRANK S. CLARK of the Stone & Webster Engineering Corporation will represent his company at the World Power Conference to be held in Berlin this summer and will visit several European countries to study the state of the art in steam power station design.

TOWN OF BROKEN BOW, Nebr., is constructing a new one-story brick and concrete 51 by 51-ft. power house, into which will be moved from the old plant the two Fairbanks-Morse 220-hp. units and where also will be installed the new Fairbanks-Morse 360-hp. unit just purchased, together with new General Electric switchboard. Completion of the work by June 15 is expected by General Superintendent F. A. Raasch.

JAMES C. ELVERSON was recently appointed general manager of the American Viscosimeter Co., Inc., New York, a subsidiary of the General Motive Control, Inc., according to an announcement from Joseph Leopold, president. Mr. Elverson has been associated with the Motometer Co. since 1920, as general manager of the industrial division.

JAMES H. CALDWELL has been elected chairman of the board of The Ludlow Valve Mfg. Co., Troy, N. Y., with which he has been associated as a general manager for 41 yr., during 27 of which he was also president of the company. The presidency of the company has been filled by the election of William H. Lolley, who is also director and general manager.

TEXAS CONSTRUCTION CO., subsidiary of the Texas Power & Light Co. of Dallas, Texas, has awarded the Austin Co. of Texas the contract for design and construction of a warehouse in connection with its power plant at Trinidad, Texas.

DAMPNEY CO. OF AMERICA, Hyde Park, Boston, Mass., announces that Edward L. Clark, formerly with Westinghouse Electric & Mfg. Co. and H. R. Kent Engineering Co., will be in charge of its New England territory, maintaining his offices in Boston.

HILL CLUTCH MACHINE & FOUNDRY CO., Breakwater Avenue, Cleveland, Ohio, announces that its New York office has been reopened. A. L. Whiteside, the engineer in charge, has been connected with the main plant at Cleveland for several years.

C. J. TAGLIABUE MFG. CO., Brooklyn, N. Y., announces its acquisition of the American Tobacco Co. property on Park Avenue in Brooklyn. From a great manufacturing plant in Bush Terminal, the company enlarges to more than double its present facilities in its projected removal to Park Avenue. The new building, a model of the latest industrial construction, will be occupied about the first of July. It is a five-story, basement and pent house, modern concrete, fireproof structure covering the entire block front on Park Ave., from Nostrand Ave. to Sanford St. The plot measures 200 by 234 ft., and the building provides approximately 300,000 sq. ft. of working floor space.

D. CONNELLY BOILER CO., Cleveland, Ohio, announces the establishment of a New York office at Room 912, Lincoln Bldg., 60 East 42nd St., New York City, with J. G. Coutant as district manager of sales. The company has also established an office at Room 1444, 20 North Wacker Drive Bldg., Chicago, Ill., with H. A. Telander as district manager of sales.

CHAIN BELT CO., Milwaukee, Wis., has moved its New York office into new and larger quarters. For a number of years this office was located at 50 Church St. The new quarters are in the new Chrysler Bldg., 405 Lexington Ave., New York City. W. H. Quinn is New York district manager.

GENERAL REFRACTORIES CO., Philadelphia, Pa., has appointed Harry N. Crowder, Jr. Co., Easton, Pa., as its exclusive dealer in Lehigh and Northampton counties in the State of Pennsylvania, also those portions of Warren and Hunterdon counties in New Jersey adjacent to the Delaware River between the towns of Belvidere and Milford.

RALPH R. NEWQUIST has been appointed sales engineer of the Chicago office of the Reliance Electric & Engineering Co., Cleveland, Ohio.

TEXAS CO. announces the removal of its New York office to 135 East 42nd St., New York City, effective April 7, 1930.

DEARBORN CHEMICAL CO., Chicago, Ill., announces that its Indianapolis office is now located at 823-824 Occidental Bldg., Illinois and Washington Sts., Indianapolis, Ind.

ALLIS-CHALMERS MANUFACTURING CO., Milwaukee, Wis., announces the removal on April 25, 1930, of its Chicago district office to 20 N. Wacker Drive, Civic Opera Bldg., Suite 3101, Chicago, Ill.

TERRY STEAM TURBINE CO., Hartford, Conn., announces the appointment of T. G. Hart as general sales manager of the company. Mr. Hart has been associated with this company since 1919 and for several years has been manager of its Chicago office. From now on, he will be located at Hartford, Conn.

OSTER MANUFACTURING CO. of Cleveland, Ohio, is now equipping all Willie-Williams portable power threaders with Domestic Electric universal motors formerly used only on the Oster Power Boy Threader, according to a recent announcement. It is claimed by the manufacturer that this new motor not only speeds up the production of the machine but also eliminates any tendency toward stalling because the speed of the motor is in direct proportion to the pull on the dies. The Willie Williams can now be furnished in either the bench type or pedestal type. Both types are designed to thread, cut, ream and chamfer all sizes of pipe from ¼ in. to 2 in.

METER DEVICES CO. of Canton, Ohio, is now in production at its new location at 3115 Tuscarawas West, Canton, Ohio. This company was formerly identified with the Superior Switchboard and Devices Co. of the same city. T. J. Newman, former president of Superior is now at the head of the Meter Devices Co.

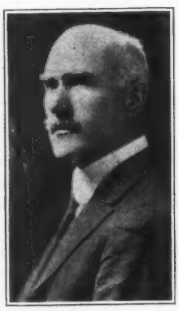
H. D. CONKEY & CO., Mendota, Ill., announces that the name of its manufacturing division has been changed to Conco Crane & Engineering Works, division of H. D. Conkey & Co.

MODERN COAL BURNER Co. announces the appointment of T. A. Marsh as president, effective May 1. For the past seven years Mr. Marsh has been western engineer and district representative of Combustion Engineering Corp. and before that served for 10 yr. as chief engineer of the Green Engineering Co. The Modern Coal Burner Co. is a subsidiary of the Peabody Coal Co. New quarters of the sales and engineering divisions will be located at 3733 Lincoln Ave., Chicago, Ill.

MASON T. WHITING has recently joined the Stone & Webster Engineering Corp. as engineer in the hydraulic division at the Boston office. Mr. Whiting came from Charles T. Main, Inc., with which concern he had long been connected on hydroelectric investigations and developments both in this country and in Africa.

WAGNER ELECTRIC CORP., St. Louis, Mo., announces the addition of Albert Shaw to its Salt Lake branch office sales force. Mr. Shaw is a mining engineer. Born in Scotland, he learned his profession at the London (England) School of Mines and gained his early experience in the coal mines of Scotland and the metal mines of South Africa. Later he served as superintendent of one of Utah's coal mines, from which he just recently transferred his activities to the Wagner Electric Corp.

EDWARDS R. FISH joined the Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn., on May 1, as chief engineer of the boiler division, according to an announcement by the company. For some time past, Mr. Fish has been consultant to the boiler engineering department of Combustion Engineering Corp. Previous to that he was vice-president of Heine Boiler Co. before it was merged with Combustion Engineering Corp. For many years, he has been a member of the boiler code committee of the American Society of Mechanical Engineers. He is chairman of the society's sub-committee on unfired pressure vessels, a member of the power test code committee and chairman of the sub-committee on boiler testing. He is a former president of the American Boiler Manufacturers' Association, is now director of the American Uniform Boiler-Law Society and has been on the council of the A. S. M. E. Mr. Fish is a native of Georgia and received his mechanical engineering degree at Washington University.



EDWARDS R. FISH

S. MORGAN SMITH Co. announces that its Chicago office, in charge of Harry T. Porter, has been moved from the Monadnock Bldg. to Room 1516, 20 North Wacker Drive Bldg., Chicago, Ill.

STOCKHAM PIPE & FITTINGS Co., Birmingham, Ala., announces the appointment of Germer Petesch as assistant general sales manager, with headquarters in Birmingham.

STERLING ICE & COLD STORAGE Co., Sterling, Colo., is completely modernizing its plant. In the future it will purchase its power from the Colorado Public Service Co. The new plant will contain two York 20-t. units of compressors driven by G. E. 40-hp. a.c. motors. Pennsylvania air compressors and G. E. switchboard will be installed. Also Shepard 2-can hoist and crane, 18-t. ice tank and the National Water Softener. York Ice Machinery Corp. is making the installation. R. A. Miller is chief engineer of the Sterling Co. plant.

ANNOUNCEMENT IS made by Cutler-Hammer, Inc., Milwaukee, Wis., that effective May 1, it has purchased the assets of Union Electric Manufacturing Co., also of Milwaukee. Branch sales offices and warehouse stocks of the two companies will be consolidated immediately and the present factory of Union will be operated as a manufacturing division of Cutler-Hammer. E. F. Le Noir, president of Union, will become a member of the headquarter sales staff of Cutler-Hammer. Most of the Union personnel, particularly those in the sales and engineering departments, will also join the C-H organization.

Books and Catalogs

MECHANICAL EQUIPMENT OF BUILDINGS, Vol. 1, Heating and Ventilation, 2d Edition, by L. A. Harding and A. C. Willard; 963 pages; flexible leather; 6½ by 9⅛ in.; published by John Wiley & Sons, 440 Fourth Ave., New York; price, $10.

In completely revising and modernizing the first volume of this standard text book and handbook, the authors have done a splendid job that needed to be done, as the first edition of this work was published in 1916 and the developments in heating and ventilation since that time have been remarkable. The present revised edition should be on the shelf of every engineer who has heating and ventilation problems of any kind. It not only contains discussion of the fundamental principles of each phase of the subject but also presents practical problems showing how the principles are applied, together with tables of constants, capacities of equipment, curves showing relations of factors, diagrams of equipment and all other data necessary to cover practical conditions.

Most of the chapters contain new material to bring them up to date. Chapters on boilers and heaters, draft and chimneys, heat transmission, steam and hot water heating, ventilation, air conditioning and the like have been rewritten while new chapters have been introduced on estimating seasonal heating requirements of various types of buildings, on electrical heating and on water, steam and air. Details of equipment shown throughout the book have been brought down to date. In short, almost every heating or ventilation problem arising in the average industrial plant, office building, hotel, school or institution is fully covered in such a way that the engineer can find a similar problem worked out in the text and can substitute his own data, select the proper constants from tables or curves and secure the correct answer.

TREATISE on the new, molecularly dehydrated, boiler water conditioning chemical, Hagan Phosphate, by Dr. R. E. Hall, is contained in booklet entitled Scientific Research Solves the Boiler Water Conditioning Problem, now being distributed by Hagan Corp., Pittsburgh, Pa. Some of these basic principles, as outlined by Dr. Hall, are that: foaming is due to concentration of soluble salts rather than to accumulation of solids; results in boiler water conditioning are subject to exact control; chemical treatment of boiler water should be carried only to the point where scale formation is prevented. Dr. Hall outlines how to reduce boiler alkalinity at will by introduction into the feedwater of this practically neutral chemical, which also provides phosphate to prevent scale formation on the boiler surfaces.

REWRITTEN EDITION of Bulletin 660 on Metered Combustion Control for Boiler Furnaces (Gibson System) is now being issued by Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

BEGINNING THE SECOND CENTURY is the title of an attractive 20-page bulletin produced in celebration of the invention of the platform scale by Thaddeus Fairbanks. It tells the story of the development of the scale and gives many interesting data on scales of the past and present. It is published by Fairbanks, Morse & Co., 900 South Wabash Ave., Chicago, Ill.

ECONOMY Blow Guns and Forge Blowers, in which the compressed air operating the gun entrains atmospheric air, to reduce air consumption, are described and illustrated in Bulletin 4-T by Schutte & Koerting Co., Philadelphia, Pa.

NICKEL-CHROMIUM Steel for High-Temperature Service in Valves and Bolts is the subject of a paper by V. T. Malcolm, metallurgical engineer, The Chapman Valve Mfg. Co. This is published as Bulletin 15 by The International Nickel Co., Inc., 67 Wall St., New York.

PLIBRICO JOINTLESS FIREBRICK Co., 1836 Kingsbury St., Chicago, Ill., is distributing copies of a new catalog entitled Cutting Furnace Costs. The catalog completely describes the use of Plibrico Furnace Lining for monolithic furnace construction. It is 40 pages in size, illustrated with over 80 illustrations. A 10-page section gives specifications for the installation of monolithic linings in connection with the more common types of boilers. Simple instructions for determining the amount of material required for any job are also included.

COPES Type DS Governor and Type RG Regulator are described in two illustrated bulletins issued by Northern Equipment Co. The governor, for use with all types of feed pumps, is shown by phantom views and its operation is explained. The regulator is designed to maintain correct predetermined pressure differential across the control valve. Its application to various boiler feed conditions is explained.

INFORMATION needed to design, install and maintain Morse Silent Chain Drives is given in its new data book, Bulletin 38, by Morse Chain Co., Ithaca, N. Y. Pitches, horsepower ratings, and dimensions are given in tables. Selection of sprockets and

the cutting of teeth for them are described. Prices are given, not only on the regular Morse line, but also on special chains, sprockets and so on. The book also goes into the subjects of Morse chain speed reducers and Morse flexible couplings at some length, showing their practical application to every-day power transmission jobs.

HYPRESSURE JENNY, a device for cleaning with heat, pressure and cleaning compound, is described in a new bulletin issued by Homestead Valve Mfg. Co., Coraopolis, Pa.

INGERSOLL-RAND Type 15 single-stage, vertical plate valve air compressors are described in a recent well illustrated bulletin, showing details of the compressors, issued by Ingersoll-Rand Co., 11 Broadway, New York.

DEFENDER Automatic Combustion Control for Fuel Saving in the Boiler Room is the title of Catalog No. 11, a group of bulletins describing the equipment, bound in a folder and published by Defender Automatic Regulator Co., St. Louis, Mo. Bulletin DD shows improved design of furnace draft regulator; Bulletin AA describes changes in the Model AA master damper regulator; Bulletins BB and CC describe extra heavy and double lever model regulators respectfully while other bulletins describe accessories and show how equipment is installed.

COAL AND ASH HANDLING, Publication 036, has just been issued by the Prime Movers Committee, National Electric Light Association, 420 Lexington Ave., New York. The report includes statements on recent installations and improved equipment available. Recent practice indicates a trend toward ash removal by water sluicing. Slag-tap furnaces are being introduced for certain conditions. Careful consideration is being given to removal of cinders and fly ash from flue gas.

IN A WELL-ILLUSTRATED 24-page bulletin, Hytempite in the Power Plant, uses of this product for boiler settings, baffles, repairs and the like are discussed by Quigley Furnace Specialties Co., 56 West 45th St., New York. Method of making monolithic baffles is shown, use of the Quigley refractory gun for furnace walls and arches and for building and repairing baffles.

AMERICAN Temperature and Pressure Controllers are described in catalog 2200, recently issued by Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn. Details of the controllers are given with phantom views of the interior construction, tables of capacities and dimensions and price lists.

ELLISON air filter gage, pointer type, is described in Bulletin 14 and pointer draft gage, straight line movement, in Bulletin 10-B, by Ellison Draft Gage Co., 214 West Kinzie St., Chicago, Ill.

MERCON REGULATORS, their construction, method of operation and applications, are discussed in an attractive 24-page catalog, No. 4, by The Mercon Regulator Co., One La Salle St., Chicago, Ill. The Mercon principle, employing a mercury column to balance the diaphragm, is first discussed, details of the parts of the device are given and then its applications as constant excess or reduced pressure regulator, constant flow regulator and so on are illustrated and described.

FIRST TWO articles of a series of six by Joseph Harrington on efficient firing of small boilers are being issued in leaflet form by Whiting Corp., Harrington Division, Harvey, Ill. The first article is entitled Continuous and Automatic Ash Discharge; the second, An Even Fuel Bed and What It Means to You.

RELIANCE Motor-generator Sets in sizes from one to 100 kw., driven by squirrel-cage motors, are described and illustrated in Bulletin 500 by Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio. Sets from 50 to 150 kw. in size driven by synchronous motors are also described.

MCNEILL LIQUID LEVEL GAGE of improved design for use with pressures up to 1400 lb. per sq. in. is described in a recent circular by Boiler Room Improvement Co., 549 W. Washington St., Chicago, Ill.

DUST PROBLEMS, an analysis of the problem in general and as applied to representative cases, has recently been issued in an enlarged second edition, priced at $1 by Dust Recovery, Inc., 15 Park Row, New York City. This 68-page book is not intended to be a catalog, as it does not describe manufacturers equipment, but is designed as a text on the subject. It discusses dust itself, methods of collecting and testing dust samples, efficiency of dust collectors, industrial appliances and gives general engineering data on collectors and their operation.

EVACTOR Steam Jet Air Pump is described and illustrated in a 14-page catalog, No. 102, by Croll-Reynolds, Inc., 17 John St., New York City. It describes two and three-stage evactors, shows interior construction, discusses the combined intercooler and aftercondenser and presents general information on steam jet pumps. The evactor thermo-compressor is also described.

REBUILT MOTORS, generators, turbines, compressors and other power plant equipment of all types, sizes and makes, available for sale, are listed in detail in a 68-page Bulletin, No. 37, just issued by Rockford Power Machinery Co., 620 Sixth St., Rockford, Ill.

DETERMINATION OF THE ENDURANCE LIMIT of a metal under repeated stress by the regular long-time method involves the testing of at least six specimens. The time required for a fatigue test of ferrous metals is about one week, and for some nonferrous metals as much as a month or more. Various short-time tests have been proposed, such as short-time high stress tests, rise-of-temperature tests, running deflection tests, and power input tests. The difficulty with all these tests seems to be that they detect slip rather than the starting of a fatigue crack. Bulletin No. 205 of the Engineering Experiment Station of the University of Illinois contains the results of an investigation of the Ikeda electrical resistance method for determining endurance limit under repeated stress in connection with reversed-flexure fatigue tests of Armco iron, 0.20 and 0.52 carbon steel, hardened tool steel, brass, monel metal, and copper. Copies of Bulletin No. 205 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Ill.

DIESEL ENGINES in Central Stations are described and well illustrated in Bulletin 129, a 42-page publication of McIntosh & Seymour Corp., Auburn, New York. The text consists largely of data on Diesel engine performance and operating considerations, analysis of costs and data on fuel consumption, utilization of waste heat and so on. Illustrations are mostly of installations of the company's engines.

PROCEEDINGS of Third Iowa Power Industrial Conference held April 2nd, 3rd and 4th, 1929, under the auspices of the University of Iowa, Iowa City, Iowa, have been published as Bulletin 239, dated March 1, 1930, and can be obtained from the Extension Division of the University for $1.00.

BULLETINS DESCRIBING the most effective means for priming centrifugal pumps manually are now available. The following subjects are fully covered in these publications: The Theory of Priming, Submerged Pumps, The Use of Foot Valves, Air, Steam, and Water Ejectors, Hand Operated Priming Pumps, Motor Driven Priming Pumps, Arrangement of Intake Piping. Engineering data, curves, tables and diagrams of connections are given. The complete set of bulletins, bound in looseleaf form, may be had by writing to Barrett, Haentjens & Co., Hazleton, Pa.

FULLER LEHIGH pulveriving mills of both air and screen separation type are described in a new bulletin, No. 902, by The Fuller Lehigh Co., Fullerton, Pa.

HAYWARD electric motor bucket, designed to be hooked on any standard crane, the bucket being operated by a motor built into it, is described in Bulletin 700 by The Hayward Co., 50 Church St., New York. In Bulletin 654, the company describes the Class K digging clam shell bucket.

TO EXPAND further its program of safety education among both employes and the general public, the Empire State Gas and Electric Association of New York requested its member organizations to furnish detailed information on the activities they were undertaking along these lines. Replies were received from 24 companies or systems having 55,287 employes and furnishing 90 per cent of the service in New York State. These replies were referred for study and analysis to the Policyholders' Service Bureau of the Metropolitan Life Insurance Co., whose Safety Service is conducting a series of investigations of the safety work which is being conducted by specific industries. The findings of this survey have been incorporated into a report entitled A Study of Safety Activities in Gas and Electric Utilities. Discussed in its pages are such subjects as Central Safety Committees; Workmen's Safety Committees; Safety Publicity; Records and Rules; First Aid; Suggestion Systems and other related topics. A limited number of these reports are available and may be secured by addressing the Policyholders' Service Bureau, Metropolitan Life Insurance Co., One Madison Ave., New York City.

STEAM CONDENSERS and auxiliaries of all types are covered in a combined 125-page text book and catalog just issued by C. H. Wheeler Mfg. Co., Philadelphia, Pa. The booklet describes and illustrates equipment manufactured by this company and outlines the theoretical and practical considerations involved in design and application of equipment of this type.

GRAPHIC INSTRUMENTS, Type AG for alternating current, DG for direct current, in switchboard, wall and portable types are described in Bulletin 830 by Roller-Smith Co., 233 Broadway, New York.

PNEUMATIC Water Supply Systems for buildings are described and illustrated in Bulletin 111 by Chicago Pump Co., 2336 Wolfram St., Chicago, Ill. This company has also issued Pump Guide No. 12, describing centrifugal pumps and air compressors.

Power Plant Construction News

Calif., Oakland—The Cutler-Lobingier Packing Co., Ontario, Calif., plans installation of electric power equipment in new fruit cannery and packing plant on Fifty-seventh Avenue, Oakland, entire project to cost more than $300,000, with equipment. The Austin Co. of California, 1924 Broadway, Oakland, is engineer.

Calif., Pittsburg—The California Western Fish Co., plans installation of electric power equipment in proposed rebuilding of portion of plant, recently destroyed by fire with loss reported in excess of $100,000.

Fla., Ocala—The City Council is said to be planning extensions and improvements in municipal electric light and power plant, including installation of additional equipment. Estimates of cost will soon be made.

Ill., Winnetka—The Byllesby Engineering & Management Corporation, 231 South La Salle Street, Chicago, Ill., engineer, has plans under way for a steam-operated electric generating plant at Winnetka, understood to be a municipal project, reported to cost about $350,000, with equipment.

Ind., Anderson—The Guide Lamp Corporation, Anderson, a subsidiary of the General Motors Corporation, Detroit, Mich., plans installation of electric power equipment in proposed addition to automobile lamp manufacturing plant, entire project to cost over $200,000.

Ind., Bluffton—The Hoosier Milk Condensory, Bluffton, plans rebuilding of portion of boiler plant, recently destroyed by fire, caused by an explosion. Estimate of loss has not been announced.

Iowa, Nevada—The Common Council is planning installation of a water softening plant for municipal water service, estimated to cost bout $20,000.

Mass., Cambridge—The Board of Trustees, Harvard University, has filed plans for a one-story steam power plant at medical school, 62x74 ft., with L-extension, 20x34 ft., reported to cost over $50,000, with equipment. Densmore, LeClear & Robbins, Park Square Building, Boston, are architects.

Mass., Springfield—The Springfield Ice Co., has filed plans for a one-story ice-manufacturing plant, reported to cost about $35,000, with equipment. Brutus Gundlach, 101 Park Avenue, New York, is engineer.

Mich., Detroit—The Union Carbide & Carbon Co., 30 East Forty-second Street, New York, plans installation of electric power equipment in proposed acetylene gas plant on nine-acre tract of land at Detroit, recently acquired, reported to cost more than $100,000.

Mich., South Haven—The Department of Public Works. City Hall, has approved plans for an addition to municipal electric light and power plant, including improvements in present stations, estimated to cost about $100,000, with equipment. Giffels, Hamilton & Weeber, Grand Rapids National Bank Building, Grand Rapids, are consulting engineers.

Mo., Butler—The Clinton Ice Co., is said to be planning construction of a one-story ice-manufacturing and cold storage plant to cost about $30,000, with equipment.

Mont., Lewistown—Chicago, Milwaukee, St. Paul & Pacific Railroad, St. Paul, Minn., is said to be planning the construction of a water storage and distributing plant at Lewistown. Estimates of cost will soon be made.

Neb., Insley—It is reported that the village of Ansley will install a new diesel engine by the fall of this year. The present capacity is diesel 150 hp., hydro 65 hp. Mr. Floyd E. Junk is Supt. and Mr. R. F. Patterson is Chief Engineer.

N. J., Belleville—The Wallace & Tiernan Co., Inc. 11 Mill Street, plans installation of electric power equipment in new addition to chlorine control apparatus plant, entire project to cost about $200,000. Fletcher Thompson, Inc., 31 Fulton Street, Newark. N. J. and 542 Fairfield Avenue, Bridgeport, Conn., are architects and engineers.

N. J., Elizabeth—The Thomas & Betts Co., 15 Park Place, New York, plans installation of electric power equipment in proposed three-story plant at Elizabeth, for manufacture of electric conduits, fittings, etc., entire project to cost more than $100,000. Lockwood, Greene Engineers, Inc., 100 East Forty-second Street, New York, is engineer.

N. J., Perth Amboy—The General Cable Co., 420 Lexington Avenue, will install electric power equipment in new one and two-story addition to plant at Mechanic and High Streets, Perth Amboy, operated by the Standard Underground Cable Co., a unit of first noted organization, entire project to cost over $300,000.

N. Y., Brooklyn—The Savoia Macaroni Mfg. Co., 1535 Sixty-third Street, plans installation of electric power equipment in proposed three-story factory addition, entire project to cost about $100,000. F. Savignano, 6005 Fourteenth Avenue, Brooklyn, is architect.

N. D., Harvey—The Central Power & Light Co., Dubuque, Iowa, is said to be planning early construction of a steam-operated electric generating plant at Harvey, to cost over $150,000, with transmission system.

Ohio, Cleveland—The Lorain Automatic Icer Co., 3953 St. Clair Avenue, plans installation of electric power equipment in proposed addition to refrigerator manufacturing plant to cost close to $100,000. The H. K. Ferguson Co., Hanna Building, is engineer.

Okla., Erick—Hill & Anderson, 10 East Tenth Street, Oklahoma City, operating the Erick Ice Co., have approved plans for a new ice-manufacturing plant at Erick, reported to cost about $25,000.

Okla., Oklahoma City—The Phillips Petroleum Co., Bartlesville, Okla., plans installation of electric power equipment, air compressors, and other mechanical equipment, in new gasoline refining plant in oil field near Oklahoma City, entire project reported to cost over $150,000.

Okla., Shattuck—The Common Council is said to be planning the installation of pumping equipment in connection with installation of a municipal waterworks, for which plans are being drawn by the Wood Engineering Co., Perrine Building, Oklahoma City, Okla., engineer. Estimates of cost will soon be made.

Pa., Midland—The Pittsburgh Crucible Steel Co., Midland, will install electric power equipment in proposed new blooming mill addition, to cost over $600,000, for which superstructure will soon begin.

Pa., Pittsburgh—The Jones & Laughlin Steel Corporation, has filed plans for a one-story boiler plant at steel mill on Second Avenue, near Bates Street, to cost about $100,000, with equipment.

Que., Drummondville—The Dennison Mfg. Co., Framingham, Mass., has approved plans for a steam power plant at proposed new factory at Drummondville, entire project to cost more than $110,000.

S. C., Pickens—The Southern Power Co., Charlotte, N. C., is said to have closed negotiations for purchase of municipal power plant at Pickens, and plans extensions and improvements for central station service, including installation of additional equipment.

S. C., Winnsboro—The Winnsboro Mills, an interest of the United States Rubber Co., Broadway and Fifty-eighth Street, New York, plan installation of electric power equipment, in connection with proposed expansion program at fabric mill to cost about $200,000.

Texas, Amarillo—The Southwestern Public Service Co., Amarillo, has begun extensions and improvements in local steam-operated electric power plant to double present capacity, developing a total output of about 30,000 hp.

Utah, Price—The Common Council has preliminary plans under way for a municipal electric light and power plant to include a Diesel engine-generator unit. Estimates of cost will soon be made.

Va., Ampthill—The Du Pont Cellophane Co., River Road, Buffalo, N. Y., plans installation of electric power equipment in proposed transparent paper mill at Ampthill, near Richmond, entire project to cost $3,000,000; a boiler plant is planned. Company is a subsidiary of E. I. du Pont de Nemours & Co., Wilmington, Del.

Wis., Milwaukee—The Briggs & Stratton Corporation, Milwaukee, plans installation of electric power equipment in proposed addition to automobile equipment plant, entire project to cost about $75,000.